OTTAWA, February 20, 1922.

The Hon. J. A. ROBB,

Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, Ottawa, Ont.

SIR,—I have the honour of presenting to you herewith the report on the work of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1921.

This report has been prepared by Dr. A. B. Macallum, F.R.S., who served as Administrative Chairman for a portion of that year.

Your obedient servant,

R. A. ROSS,

Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research.

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REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

I. GENERAL ACCOUNT OF THE WORK OF THE COUNCIL

1. *Meetings of the Council—General Observations.*—There were nine meetings of the Council and all, with one exception, were held in Ottawa. Each of these involved a session of two days and the attendance of the members averaged seven, a high number in view of the long distances that several of the members had to travel in order to be present. As in each of the three preceding years the members through committees devoted a considerable amount of time between the meetings to the work of such committees, and this service facilitated very greatly the work of the Council in its sessions.

The members of the Council serve in a purely honorary capacity, receiving no remuneration for the work they do. The time which they have given to attendance at the meetings, including also that spent in going to and returning from Ottawa, amounted in the case of the majority of the members to nearly a month, in some considerably more than that, all taken from the time which, otherwise, would have been given to the pursuit of their own professional callings. This sacrifice has been prompted by the hope, a keen one, that the work which they have done, and are doing, has been, and is still further to be, of inestimable value in the institution in Canada of an organization which will be an all-important factor in promoting the development of the industries of the Dominion and in utilizing its natural resources in the creation of the wealth necessary to lighten the great burden of debt which Canada will have to carry for the next fifty years at least. Any measure that will, when carried out, achieve this object in the next ten years will relieve the anxieties of all who have at heart the interests of the country and all who assist in the promotiou of this result will feel that they have, in some degree at any rate, been its benefactors. That explains the willingness of the members of the Council to make the sacrifice of their time and energies.

It must be confessed that the hope which stimulated the Council in its work from 1916 on, during the early part of last year seemed in danger of defeat. The organization which the Council aimed at promoting was a National Research Institute for Canada, in which would centre many of the activities in research concerned in the industrial and mineral development of the country. The recommendation that such an Institute be established had a general, practically a unanimous, approval throughout the Dominion. Boards of Trade, Clubs, Canadian and Rotarian, and scientific organizations, enthusiastically endorsed it and two committees of the House of Commons, one for each of the sessions of 1919 and 1920, composed of members of both sides of the House, appointed to enquire into and report on the

measures which should be taken to promote scientific research in application to the development of the resources of the Dominion, in two reports strongly urged the acceptance by Parliament and the Governor in Council of this recommendation, which reports were unanimously approved by the House on both occasions. Towards the end of the session of 1920, therefore, there seemed to be a fair prospect of this National Research Institute being established by legislation undertaken to this end. The Government, however, failed to take action before Parliament was prorogued in June, and, as might be supposed, the Council, after three years of effort to attain the cardinal object of its aim, felt that its achievement was in danger of being indefinitely delayed.

The supposed set-back, however, was only temporary for in September came assurances to the Council, which were welcomed, that the Government would at the next session undertake to provide legislation establishing the proposed National Research Institute. These assurances were made good by the action of the Government in introducing into the House of Commons a Bill along the lines of the draft Bill proposed by the Council, which if it received the assent of the Governor General would very soon result in the development of a Research Institute for Canada which would greatly enhance the industrial efficiency of the country.[1]

The Council, it may be freely confessed, is not infallible and it has never claimed to be, but its members are disinterested and, what is of special importance, their training along scientific lines and their experience in scientific work qualify them for the role of advisors as to the type of organization for research which the Dominion requires if it is to keep step with the advances made abroad to promote industrial research as an aid to national prosperity. They naturally expect, and the intelligent portion of the public will also expect that their recommendation will receive some measure of recognition as otherwise the Council would have no justification for its existence.

The Council still hopes that the National Research Institute will be founded, and it is of the opinion that the forward-looking section of the public of the Dominion hopes likewise. That hope supplies the incentive to the members of the Council to continue in a service which has involved a sacrifice not only of their time and energies but also, to no small degree, of their own interests.

2. *The Standing Associate Committees.*—Each of these Committees held meetings during the year.

The Associate Committee of Chemists which met in Toronto on May 29-30, 1920, under the chairmanship of Professor R. F. Ruttan, was attended by sixteen of its twenty members. It discussed a large number of subjects of special interest to those concerned in the development of chemical research and of the chemical industries in Canada and amongst these the following:—

1. Legislation regarding industrial alcohol.
2. The recovery of waste paper.
3. The alkali and salt deposits of the Northwest.
4. Studentships and Fellowships to assist those training for careers in research in Canada.
5. The education of the chemical engineer.
6. A Reference Scientific Library for Canada.

The Associate Committee on Mining and Metallurgy met in Montreal on February 4, 1921, under the chairmanship of Professor Frank D. Adams. Ten members were in attendance. The subjects dealt with in this meeting included the following:—

1. A Central Information Bureau at Ottawa.
2. The preparation of peat in Canada for domestic fuel.
3. The utilization of Canadian iron ores.

[1] The subsequent history of this Bill will come within the scope of the Report of the Council's activities for 1921-22. It may, however, be very briefly set out here. This Bill was accepted almost unanimously by the House of Commons and was given its Third Reading on May 10th, but it failed later to pass the Senate.

The success which has so far attended the operations to produce peat for domestic fuel at the Alfred bog was reported by Wm. Cole, the chairman of the Ontario Peat Committee, who stated that about five thousand tons of manufactured peat which had been produced at the bog during the year had been sold in the city of Ottawa and in some twenty-five of the smaller towns in the various parts of Central Canada. The peat so prepared met with a ready sale and he stated that the market demand was such as to take, if it were available, ten times the output. The product sold readily in Peterborough at $13.50 per ton, in Ottawa for $9 a ton, and a shipment of it went as far east as New Brunswick. Indeed certain manufacturers offered to take the entire output at a higher price than had been fixed but this was not accepted as the object of the Peat Committee was to introduce peat for domestic purpose. The success so far achieved was encouraging but another year's operations were necessary in order to demonstrate finally that the production of peat for domestic fuel is a practical proposition. So far the work done had received the approval of Dr. Purcell, acknowledged as the leading British authority on peat, who, representing the Honorary Advisory Council for Scientific and Industrial Research of Great Britain, had investigated the work of the Committee at Alfred and reported that Canada was further advanced in the development of peat production than any other country in the world.

To continue this work for one more year it was necessary that a further appropriation be provided and a resolution strongly recommending that the Government make this additional grant received the unanimous approval of the Associate Committee.

On the subject of the utilization of Canadian iron ores the Committee had in 1920 appointed a sub-committee with the object of investigating this question and to demonstrate that such ores can be utilized and put on the market commercially. The sub-committee has confined its efforts for the time to practical problems and as 98 per cent of the ore mined is used by blast furnaces the sub-committee reported that they should confine their investigations to the use of Canadian iron ores in blast furnaces and that the question of the electric furnace in connection with such ores should be left for future investigation. A report on the results so far obtained by this sub-committee was forwarded to the Research Council.

A report of the work of the Committee in its investigation of the possibility of utilizing these ores is given in appendix "A."

The formation of an Associate Committee on Physics and Engineering Physics was approved by the Research Council at a meeting held on December 12, 1919, in order that such a body should act in a consultative capacity to the Council on problems in these two departments of science and, in consequence, such a Committee was subsequently appointed whose membership is indicated elsewhere in this report. Two meetings of this Committee under the chairmanship of Prof. J. C. McLennan, F.R.S, were held during the year, one on May 21, 1920, in Ottawa, the other on January 14 and 15, 1921, in the Physical Laboratory of the University of Toronto. Reports of the proceedings of the two meetings of this Committee are given in appendix "B."

3. *The Expenditures of the Council.*—The parliamentary vote for the year was $120,000 and the net expenditure was $109,577.48, leaving a credit balance of $10,522.52, which was returned to the Receiver General at the end of the year. This exceeded the expenditure of the preceding year by $9,705.06. This was due to a larger number of grants for assistance for special researches, which amounted to $48,779.05, and $9,000 was used to purchase, from the Imperial Munitions Board, apparatus (standard gauges, etc.), which originally cost nearly three times as much, and which will prove very serviceable in the Research Institute when it is established. There was a net expenditure of $16,925 for Fellowships, Studentships, Bursaries and Scholarships, the holders of which numbered 36 in all. Salaries amounted to $17,600.51, which was less than the total for salaries for the preceding year by $559.44.

4. *Assisted Researches.*—As stated in the preceding section, the amount expended by the Council to assist approved researches was $48,779.05, which exceeded the amount ($33,315.53) spent in the previous year by $15,463.52, due chiefly to new

researches undertaken, some of which required large grants to carry them on. The total number of grants was seventeen, or three more than the number assisted in the previous year. As in that year so for the year now under report no part of any one of the grants was expended in paying for the services of those responsible for the investigation thus assisted. The grants were used for the purchase of the material or apparatus needed and in several cases for salaries or honoraria for assistants employed either for whole or part time in attending to the details of the investigations. A list of all the researches assisted during the year is given in appendix "K."

It may be pointed out here that the comparatively small number of researches assisted is a fair indication of the availability for research work of those in the scientific staffs of the universities and of the technologists trained for research, in Canada. A very great majority of the scientific members of the staffs of the universities, are, unfortunately, in the conditions which now prevail in these institutions, overloaded with hours of instruction for their classes as well as, in some instances, with the supervisory work of their departments, and in consequence only a few have enough free time to devote to research. Further, a number of these carry on research on subjects in the "fundamental" sciences the results of which are not, or will not be immediately applicable in solving industrial technical problems, subjects which do not in many cases require financial aid from sources outside the universities themselves. The number of those qualified as well as free to undertake important researches of an urgent character for the achievement of which grants from the Council may be necessary is, accordingly, in Canada, very limited. This is one of the facts emphasizing the necessity of a National Research Institute for Canada in which a large research staff constituted for that purpose may carry on continuously investigations on problems the solution of which may be of the most pressing importance to the industrial and mineral development of the Dominion.

In the report for the year 1919-20 attention was directed to the cement problem of Western Canada, especially of the Provinces of Manitoba, Saskatchewan and Alberta. It was pointed out that the soil waters nearly everywhere in these Provinces are charged with alkaline salts which attack concrete structures and cause a decay which necessitates their renewal in the majority of cases in less than a decade and the loss so incurred amounts, it has been estimated, to a million dollars or more a year. The processes involved in this disintegration, it was stated, are unknown, although researches undertaken by the Reclamation Service at Washington, with the co-operation of the Bureau of Standards, and by cement companies and engineering associations on the causation of disintegration of cement structures of the Western States, where soil waters impregnated with alkalics also obtain, have not so far shed much light on the subject, and the subject, therefore, calls for more investigation. The Council, it was further stated, proposed to undertake an investigation of the problem as it concerns the Prairie Provinces very greatly if the proper expert organizations required could be constituted and if also, it could out of its modest parliamentary appropriation, meet the necessary expenditures which would be incurred.

The Council followed up this question by referring it to the Engineering Institute of Canada to report on how this investigation could be most effectively undertaken. This matter was considered during the Western Professional Meeting of the Institute held at Calgary in August, 1920, with the result that it recommended that $15,000 per annum for three years be secured to engage specialists to devote their entire time to this investigation and, further, that this investigation be carried on under the supervision of a committee of the Institute on the destructive effect of alkali soil waters, which committee would represent the provincial branches of the Institute in the three Prairie Provinces. The Council approved of these recommendations and granted $5,000 to assist in carrying on the investigation during the year, under the direction of Professor C. J. Mackenzie, of the University of Saskatchewan, chairman of the above named committee of the Engineering Institute, which has secured contributions amounting in all to $8,000 for this purpose from

the Canadian Pacific Railway Company, the Governments of Saskatchewan and Alberta, and the Canada Cement Company to assist in carrying on this work. The investigation, which is now in progress, is being participated in by both chemists and engineers, the problem for the former being to discover the exact reactions which lead to the disintegration, and, if possible, to provide a remedy, while the work of the engineering part of the investigating staff is to adapt all the findings so obtained to practice, to investigate thoroughly the relative part played by grading of adequate consistency, mix, permeability, and so on, and, further, providing the chemists can find no remedy the engineers must evolve standards of practice in the construction of concrete work which will neutralize in some measure the effect of alkali soil waters. It is hoped, in any event, that the results of this investigation will give results which will lessen very considerably, if not wholly prevent, the great loss incurred annually in the West through this disintegration of concrete.

A grant of $1,000 was given to Professor Wilfrid Sadler, of the Department of Dairying, of the University of British Columbia, to continue his investigation, begun in the preceding year, on the grading of dairy products (cream and butter) and to correlate this grading with the bacterial content of the milk or cream used in the preparation of these products. The object of this investigation is dealt with in the report for 1919-20. The results of the investigation at the end of that year were of such a character as to justify the Council in continuing its support of this investigation and those which have been obtained for 1920-21 constitute a distinct advance in our knowledge of the bacteria which are very important factors in affecting the production of standard quality butter in Canada. Professor Sadler has presented a lengthy interim report of his work so far, detailing what has been achieved and what he hopes will be accomplished during the coming year. The final results will, it is expected, be incorporated in a report which will appear as one of the bulletins which are published, as occasion warrants, by the Council.

A grant of $8,006 was made to the Foresty Branch of the Department of the Interior to continue the detailed forest survey conducted for the three previous years on the Petawawa Military Reservation with the object of inaugurating an investigation, more or less protracted, to determine the conditions which affect the growth of the more valuable forest trees in Eastern Canada, and to assist the establishment under the Forestry Branch on this reservation of a Forest Experimental Station which would continue this investigation for a number of years, from ten to twenty, with the object of obtaining the data necessary to the reforestation of the burnt or cut over areas in Eastern Canada. The Council now considers the results so far achieved as demonstrating the advisability of the establishment of this Forest Experimental Station and has recommended that the Department of the Interior should in its annual budget make provision for such a station at the earliest possible date.

The investigation on the nutritional problems affecting the fox-breeding industry, initiated during 1919-20, was continued during the year with the aid of a grant of $5,500 from the Council. This investigation was carried on in association with the Health of Animals Branch of the Department of Agriculture at the Research Laboratory of the branch at Hull, Quebec. Ranch accommodation on the grounds attached to the laboratory had been made for the foxes which were used in this investigation and also adequate space was accorded in the laboratory for the biochemist engaged in this investigation. The ranch attached to the laboratory affords accommodation for six pairs of foxes which have been generously donated for this purpose by a number of Prince Edward Island fox breeders. The biochemist engaged for this investigation is Mr. G. Ennis-Smith, a Canadian, who has had a very considerable experience as a biochemist in the nutrition of animals in the Agricultural Experimental Stations in Dakota and elsewhere, along lines which qualify him for this work. The experiments so far carried out have enabled him to fix, at least approximately, the maintenance ration for the fox. It is expected that the general nutrition, condition of fur, fertility and success in rearing of the

young foxes may shortly yield definite information regarding the type of diet most likely to be practically successful. The preparation of a report of the results so far obtained is in progress and it will be published as a bulletin at an early date.

A grant of $1,200 was made to the Associate Food Research Board to enable it to meet the expenses of an investigation which had for its object the isolation in a pure form of one of the so-called "Vitamines," or "Accessory Food Factors," A knowledge of these compounds began to develop after 1904, but it was only after 1912 that their importance in nutrition was recognized generally, and during the last five years a great deal of work has been done with regard to their action on the growth and the maintenance of normal conditions in animals and in the human body. One of these is known to promote growth, a second to maintain a normal condition of nerve and other tissues, while the third in a diet prevents the development of the conditions which characterize the disease known as scurvy. They must all be more or less constantly present in the diet of an individual if growth and health are to be maintained and their importance in nutrition is, therefore, unmistakable. None of these three has been isolated in a state of purity and in consequence nothing is known regarding their chemical nature except that they are not of a protein, fatty or carbohydrate character. Attempts to isolate them have failed because they occur in almost infinitesimal quantities in the foodstuffs and because also they, and especially one of them, the absence of which causes the disease known as beri-beri in man and polyneuritis in animals, are more or less subject to decomposition as they undergo purification. If they were isolated in a pure and active form it would be possible to ascertain their chemical composition and this would lead very probably to a more thorough knowledge of their action in the body and to their synthesis for use in foodstuffs known to be deficient in vitamines, an event that might result in recasting much of our present knowledge of a normal diet. That they can be prepared in a pure form is the hope that encourages the Associate Food Research Board to try new methods with this object in view confining its efforts first to the isolation of the vitamine the absence of which from a diet for a prolonged period causes beri-beri in man. When isolated the properties of this substance will be carefully investigated. Afterwards the isolation of one of the two others may be attempted.

A grant of $10,000 was made to Mr. Horace Freeman, Secretary of the British Columbia Advisory Committee of the Council, to meet the expenses of an investigation to devise an economic method for the reduction of the complex silver-lead-zinc-iron-sulphide ores of the Slocan district of British Columbia. The mines at present are required to separate the zinc as far as possible from the ore before shipment to the smelter and this can only be accomplished very imperfectly at some considerable expense. The smelter does not pay for the zinc remaining in the concentrates and makes large deductions from the lead and silver values according to the amount of zinc present, owing to its interference with the smelting process. On the other hand, when the ore is treated for zinc for the electrolytic process the lead must be eliminated as far as possible, and, moreover, in the roasting process the iron sulphides present are oxidized and give rise to zinc ferrates which are not dissolved by the acid used in the leaching process. As a result upwards of twenty per cent of the zinc is lost in this insoluble form. The loss, therefore, in either case, is great and the methods that will obviate this loss would make these ores more valuable. Mr. Freeman proposes to try electric smelting of these ores with metallic iron as a reducer and in an electric furnace of special construction, and the object would be the separation in one operation of the valuable metals and only the argentiferous lead would need further treatment. The research will be carried on under the supervision of a sub-committee of the British Columbia Advisory Committee in Vancouver, and it is estimated that it will take more than a year to obtain definite results and to bring it to a conclusion.

For a research on Ultra-Sonics under the conduct of Professor R. W. Boyle, of the University of Alberta, a grant of $2,500 was made. When acoustic (sound)

vibrations of pitch are higher than the audible, that is when they exceed 20,000 per second, they are known as "ultra-sonic." The wave lengths of such vibrations are, consequently, very short, only a few centimeters or less, and it is possible to reflect, refract and diffract them by objects of ordinary size and with appropriate detecting apparatus they may be used for signalling under water. Further, submerged objects and icebergs act as reflectors to these waves and, consequently, their presence can be disclosed by the "echo" produced by the ultra-sonic waves reflected from their surfaces. Such an "echo" is imperceptible under ordinary conditions but it can be made readily perceptible by a device to the ear and as it is carried at least one-half, probably three-quarters, of a mile it may be made the means of detecting icebergs and submerged obstructions on the paths of ships. A thorough investigation of the properties of ultra-sonics and of their utilization may yield results of great practical value in navigation and submarine operations, which constitute one of the objects Professor Boyle has in view in undertaking this investigation. The grant of $2,500 made by the Council will cover only part of the expense involved, the remainder it is understood, to be met by a grant of $2,000 from the University of Alberta.

Professor Frank Allen, of the Department of Physics, of the University of Manitoba, was allowed a grant of $1,000, to cover the cost of an optical instrument of special design for his researches in colour vision on which he has been engaged for several years. The instrument is a colour mixing spectrophotometer with a special prism designed to give three spectra in close juxtaposition or superposed as desired.

A grant of $1,000 was made to Prof. J. C. McLennan, F.R.S., to assist a research undertaken by him on Infra-Red Radiations. These waves are not detectable by sight but with the aid of certain devices they can be used for secret signalling to distances of 8-10 miles even through fogs and clouds, which they penetrate more readily than rays of visual range. Further, when these rays fall on certain substances they produce modifications therein which render them easily detectable. The aim of Professor McLennan is to investigate these rays more fully and to explore their usefulness in the direction of revealing hitherto unknown physical properties of elemental substances. The grant is to be used for buying apparatus specially adapted for this research.

To Professor McLennan another grant of $3,000 was made to continue his work on the liquefaction of helium. Professor McLennan had previously received from the British Admiralty $5,000 for this work, also $5,000 during 1919-20, and the University of Toronto had assisted to the extent of $12,000 which sum was spent in installing for this purpose a liquid air machine. The $5,000 grant by the Council in 1919-20 was for additional apparatus necessary for this work. At present experiments are in progress in the direction of liquefying helium which as liquid has a temperature within two degrees of absolute zero, and it is hoped to gain valuable information regarding the thermal, electric and magnetic as well as other physical properties of substances at very low temperatures. information which will have a direct bearing on the problem of determining the nature of the ultimate structure and constitution of matter.

A research on the utilization of the Milkweed, which is very common throughout Eastern Canada, was undertaken by Professor A. C. Neish, of the Chemical Department of Queen's University, with a view to determining its availability as a source of textile material, of its oil as a paint oil and of its coma as a filling for mattresses, pillows, etc. A grant of $250 was given to meet the expenses involved. Professor Neish had as a collaborator in this work Mr. J. W. Burns, a holder of one of the Studentships awarded by the Council.

A grant of $850 was made to assist a research on the surface energy of solids conducted by Professors F. M. G. Johnson and O. Maass, of McGill University. The surface energy of ordinary liquids has been accurately ascertained but it has been determined in only the case of one solid and then only approximately. Professors

Johnson and Maass are applying a new method in this determination which will probably yield decisive results.

A sum of $8,000 was granted to the Associate Committee on Mining and Metallurgy to conduct a survey of the iron ore supplies of Canada with a view to their utilization in the production of pig iron and steel. As a very great part of the ore smelted in Canada, in some years since 1915 as much as 96 per cent, has been imported, it is a question of great economic importance to the Dominion whether native ores can be utilized under new methods of treatment and thus help in some degree in reducing the balance of trade which obtains against Canada. A sub-committee of the Associate Committee has this survey in charge and is also engaged in ascertaining how these ores may be rendered suitable for treatment and the appropriate methods of smelting them.

5. *Fellowships, Studentships and Bursaries*:—The total number of these awarded for the year was: Fellowships, eight; Studentships, thirteen; Bursaries, fifteen. Three of those awarded Fellowships, two of those awarded Studentships and six of those awarded Bursaries, resigned them, while one Studentship and one Bursary awarded were deferred to 1921-22. Thus only twenty-three students were actually in receipt for the year of this assistance to them in their training to qualify for a career in research. The number finally holding all these did not exceed the number held in the previous year although it was expected that there would be a considerable increase. The low number awarded and the considerably lower number accepted of these awards may be explained as due in part to the modest sums which they have involved hitherto and in part to the small number of young graduates of Canadian universities qualified to receive such assistance. The amount allotted to a Bursary is $500, to a Studentship $750, and to a Fellowship $1,000. Urgent representations have been made to the Council, chiefly from members of the scientific staffs in the various universities, all to the effect that these amounts, especially those for the Bursaries and Studentships, are insufficient to maintain students while training themselves for research and that an increase in each is necessary. The cost of living in the larger university centres is high and it is a factor which should determine whether the amounts given are adequate or not for the object in view. That some of the students appear to find them adequate is indicated by the number who have accepted these Bursaries, Studentships and Fellowships, but in answer to this it is stated that not a few of these students are relying not wholly for their maintenance on what they receive from these but draw also on their own or other private resources to supplement the sums they so receive. The Council finally, after careful consideration of the subject, decided to increase the amounts given to $750 for a Bursary, $1,000 for a Studentship and $1,200 for a Fellowship, and that this scale should prevail for a couple of years or until the cost of living decreased sufficiently to permit of reducing the sums allotted to each class to the amounts hitherto fixed. This new scale will obtain for the year 1921-22 and it is expected that it will add to the number of holders of the Bursaries, Studentships and Fellowships.[1]

In the selection of students for the Bursaries, Studentships and Fellowships it must not be forgotten that the Researcher is born, not made. Further, only a small proportion, not more, and according to some experienced university teachers, much less, than five per cent of the students who graduate in science from the universities have the fundamental qualifications, initiative, imagination, and the special scientific knowledge that go to make a researcher of even mediocre capacity. This is the view of the writer of this report. When he began his university teaching career he held that almost every student who graduated in a science course could be trained to follow a career in research. The experience of the years since then has proved otherwise. Many

[1] At the time of the preparation of this Report the number awarded for 1921-22 is forty-five, nearly double the number actually held for 1920-21. The increase may not be the result of the increase in the scale of the amounts of each class for the grants to student-in-training made by the British Research Council for the current year is one hundred and thirty-two while it was only fifty-six for 1920-21, although there was no change in the scale of the grants in the two years.

may be called, but few chosen. It is a truth that must be recognized by the younger generation of professors in the scientific departments of our universities as, otherwise, their efforts may be wasted in attempting the impossible. On the other hand, the quest for those who have an inborn capacity for research should be assiduously and earnestly followed *for such, when found and trained may be counted amongst the greatest of the natural resources of a country.* Not all of these are included in the final class lists of the universities. Just as in "the dim common population" there are "mute, inglorious Miltons", so there may be mute, inglorious Faradays, and even Faraday himself had he not been so fortunate as to serve as a laboratory attendant under Sir Humphrey Davy in the Royal Institution, might have spent his life as a bookbinder, to which trade, when he attracted Sir Humphrey Davy's notice, he was apprenticed. To find a few of such, wherever they may be, and to train them, is an achievement for a teacher of science of not less distinction than that which may come from his own contributions to knowledge, however important they may be.

The Council, to assist in the discovery of such potentialities and to permit of training them adequately, established the system of Bursaries, Studentships and Fellowships. These are not eleemosynary in any respect, nor are they to be considered as stipends or salaries, and care must be taken to prevent them from being regarded as such. They are but aids to assist students of the right type to develop as capable researchers. Such will be greatly needed in the next decade if the natural resources of the Dominion are to be effectively utilized and if also Canadian industries are to hold their own in competition with their rivals abroad. If such researchers were not now being trained in our universities a large number trained abroad would have to be imported eventually. *There are many too few in the Dominion to meet even its present needs, a fact that is not generally appreciated.*

6. *Associate Committee on Industrial Fatigue.*—This Committee, which was constituted at the close of 1918, has been, after two years of activity, reconstituted to carry on work in a more limited field than that in which it then functioned. As pointed out in the last report of the Administrative Chairman, that for 1919-20, the committee "found that all the factors of industrial fatigue are associated very intimately with health and diet of the worker and hygienic conditions or otherwise of his environment, not only during his working hours, but also of his life outside the factory or workshop." In consequence, the Committee asked that its name be changed to that of Associate Committee on Industrial Hygiene. As, however, public hygiene is one of the functions of the Dominion Department of Health, then recently established, to have "investigations on subjects in certain lines in industrial hygiene carried on by a Committee outside of and not responsible to that department is contrary to the policy of the Research Council, which has scrupulously avoided any duplication of the work or of the functions of a Department in the public service." When it appeared that the work of the Committee would inevitably include investigations in public hygiene the Administrative Chairman was instructed by the Council to recommend to the Deputy Minister of Health that the Department take over and carry on the work of the committee which legitimately belongs to it. This recommendation was not accepted by the Department because its limited budget did not permit of a larger programme than that already provided for.

Early in 1920-21 the Council put itself on record according to the following Minute:—

> "The Council had under consideration a communication from the Associate Committee on Industrial Fatigue asking that the Committee be authorized to change its name to Associate Committee on Industrial Hygiene. It was moved by Sir George Garneau, and seconded by Dr. Ruttan and resolved: That whereas the Associate Committee on Industrial Fatigue was constituted before the creation of the Federal Department of Public Health, and whereas the problems engaging the attention of this committee lie within the purview of the said

Department, it is resolved that the Research Council deems it inadvisable to make any change in the name of the Committee under the present conditions; that the Council is of the opinion that after the expiration of the present fiscal year the investigations in connection with industrial fatigue should be carried out by and under the Department of Public Health and that the Department be advised to that effect."

Thus the matter stands. Meanwhile the Committee continued its work to the end of the year along the line on which it began, namely, a survey of the present situation in regard to industrial hygiene and social welfare in certain representative industries, with a view to obtaining enough data to enable it to concentrate its energies on a line of investigation distinct from any of those undertaken in the United States, Great Britain and France, and of special importance in Canada. It proceeded to investigate the general conditions of industrial hygiene in Toronto and Montreal, more particularly in the former, where seventy-six plants were kept under observation for this purpose and a large number of facts, with deductions therefrom, were collected which will undoubtedly prove to be of value in future effort along this line. These results were summarized in a report published by the Council in April, 1921.[1]

Because of the inability of the Federal Department to undertake the investigation, Professor J. J. R. Macleod brought the question of continuing this survey to its completion before the Provincial Board of Health of the Province of Ontario, and the latter eventually decided to establish an Industrial Hygiene Division, which is now in full acitivity. The functions of the Committee and two of its staff have been taken over by the Division which will in all probability justify its existence. The large collection of reports and publications on industrial hygiene collected from abroad has been placed temporarily at the service of the Division. The Committee, reconstituted with a smaller membership, is now confining itself to collecting publications and reports from similar organizations elsewhere which are engaged in studying industrial fatigue, and may, when a problem presents itself in this line which is not in the scope of any of the Departments or Boards of Health, Dominion or Provincial, undertake to investigate it.

Meanwhile, there romain problems in industrial hygiene to be solved which are of the very first importance to industrial life in Canada. Similar problems are under investigation abroad and already the results obtained are telling on conditions in many industrial centres. These results are applicable only partially to industrial conditions in the Dominion.

7. *The British Columbia Advisory Committee.*—The report of this Committee for the year 1920-21 appears as appendix "C".

Early in 1920 a number of members of this Committee had resigned or left the Province, and in consequence it became necessary to review the situation there with the object of reorganizing the Committee and enhancing its activities. One of the members most keenly interested in the work of the Committee, the chairman, Mr. R. F. Hayward, urged that a Secretary be appointed who would conduct the correspondence, prepare the list of agenda for the meetings of the Committee and attend to technical and other matters brought to its attention and also make preliminary surveys of problems in British Columbia for the consideration and action thereon of the Research Council. The Council made provision for the office expenses and the salary of a steno-typist for a Secretary, and in February, 1920, Mr. Horace Freeman was appointed in that capacity, a position which he has held and still holds. Soon after this appointment Mr. Hayward resigned his chairmanship because of his removal to Santiago, Chili, to assume there the managership of a mining company and

[1] Report No. 7. Survey of General Conditions of Industrial Hygiene in Toronto by the Associate Committee on Industrial Fatigue of the Research Council. Published by the authority of the subcommittee of the Privy Council for Scientific and Industrial Research. Ottawa, 1921.

this necessitated further changes. It was found difficult to get a representative attendance of the members at the meetings of the Committee owing to the fact that some of them live at points in the Province more or less distant from Vancouver, while the calls of their professions entailed the absence of others on the occasions of such meetings. To get speedier action on many matters which should receive the attention of the Committee but which do not involve questions of policy or principle, the Administrative Chairman recommended the appointment of a sub-committee with executive powers to act on all matters except those which should be dealt with by the Committee as a whole. This recommendation was accepted by the Council and the Committee, and the sub-committee appointed consists of the three members—Professor J. M. Turnbull, of the Department of Mining and Metallurgy of the University of British Columbia, Dr. C. McLean Fraser, of the Biological Department of that University, and Mr. H. R. MacMillan, President of the H. R. MacMillan Timber Export Company, of Vancouver.

The report of the Committee, prepared by the Secretary, given in appendix "C," deals with the results of a survey of the more outstanding industrial problems of British Columbia.

8. *The Utilization of the Flax Straw of the Prairie Provinces.*—The flax grown in Manitoba, Saskatchewan and Alberta is almost wholly that for seed, and the straw, which is cut, not pulled, when the crop is harvested, has not, except in one line and then to a negligible extent, been used as raw material to make any commercial product. The exact amount of the straw yield, annually, is not known but as it is on the average about one ton per acre and as the acreage devoted to it in 1920 and 1921 was about 1,391,076 and 516,972 respectively, the tonnage of each of these years could not have been less and may have been more. This straw, because of the character of the soil and possibly the climatic conditions under which it is grown, and because also it is cut and not pulled, is not suitable for producing high grade textiles and even if it were the dryness of the climate renders "retting" impossible, or nearly so, except in irrigated areas. The straw is almost wholly disposed of by burning it.

Early in 1920 the question of utilizing the straw for some commercial purpose was brought to the attention of the Council by the Board of Trade of Regina, by Dr. W. D. Cowan of that city, and by Mr. T. M. Malloy, Commissioner of Labour and Industries for the Province of Saskatchewan, and the Council, after consideration of the matter, decided that some investigation of an experimental character, if it could be provided for, should be undertaken with the object of determining the use to which this material could be profitably put. It was ascertained that at least one manufacturing firm operating in Duluth was using straw of a similar character produced in the Western States south of the international boundary, in combination with cotton to produce crash towelling, rugs and some other textiles. It was also known that the Arthur D. Little Company, in association with the Canadian Pacific Railway Company, had endeavoured to find some economic use to which this straw could be put, and succeeded in the production of a high grade pulp from which was made a writing paper of high quality, almost equal to a bond paper, which because of its price had only a limited market. Two lines of utilization of the straw, therefore, seemed to be possible in Canada. That in which the straw was made into fibre employed for the production of textiles of a certain character did not need demonstration as a commercial proposition. The success of the manufacture of crash towelling, rugs, etc., from it achieved by the Duluth firm was decisive on this point. The other line, involving the production of paper, had not been fully investigated and there remained the question whether the straw could be used to make other grades of paper, especially those which would command a large market, as, for example, news print. The Council decided to have an attempt made to solve this problem.

In the Industrial Institute associated with the Bureau of Standards at Washington there is a pulp and paper making outfit constructed on a semi-commercial scale which is being used to determine whether a large number of lines of raw material

from different countries can be economically used in the manufacture of paper of various kinds. Aware of the fact that such experimental work was being carried on, the Administrative Chairman asked Dr. Stratton, the Director of the Bureau, to have flax straw from Western Canada tested in the plant of the Institute to determine its value as a raw material for the manufacture of paper of all kinds on a commercial scale. To this request Dr. Stratton at once responded and agreed to receive a shipment of the straw for this purpose. Through the assistance of Major G. G. Ommanney, of the Department of Colonization and Development of the Canadian Pacific Railway Company, a quantity of this straw was shipped at the expense of the Company from Coaldale, Alberta, to the Bureau of Standards in January of 1921, where it is now being tested for its value as raw material for making paper. It will take some time before the experimental work is finished and it is possible that another shipment may be necessary, but it is hoped that in the end the results will be such as to indicate definitely whether the straw can be so utilized on a commercial basis.

If it can be so used, it will mean, possibly, the development of a new industry in the Prairie Provinces for the amount of straw available at railway shipping points, about one half of the total yield, was, it is estimated, in the neighbourhood of 250,000 tons in 1921 and 700,000 tons in 1920. Whether by special treatment news print can be made from this raw material remains to be seen.

Flax for pulling has been successfully cultivated in the irrigated areas in southern Alberta. A flax-pulling machine which has been invented and which may be so improved as to render it very serviceable, may result in an increase in the yield of pulled flax straw, for if it is profitable under certain conditions in the West to grow flax for the seed alone it will be more so in districts near shipping points if the straw is a marketable raw material.

9. The Utilization of Low Grade Lignites of Western Canada for Domestic Fuel.—The history of the formation of the Lignite Utilization Board, its relation to the Research Council, and a resumé of its work up to May 31, 1920, are to be found in previous annual reports of the Administrative Chairman.

At present the situation with regard to the Board is that it has completed the construction of its main demonstration plant near the town of Bienfait, Saskatchewan, and has made tests on the various portions of the plant and found everything to be satisfactory, with the exception of the carbonizers, upon which experiments are still being conducted.

The carbonization of lignite is the very heart and kernel of the whole problem, and until these retorts are altered in such a manner that they may be operated commercially, the rest of the project must necessarily mark time. In regard to the carbonizers, it may be said that the principle has proved sound, and the mechanical operation has been demonstrated, but owing to subsidiary and minor troubles they cannot be operated for some months yet. Every effort is being expended to bring about these minor alterations at the earliest moment, and a successful trial of the carbonizers is looked for during the coming summer. In spite, however, of the difficulties with the carbonizers the Board has been successful in turning out briquettes at its plant.

It may be noted also that carbonized lignite briquettes possess fine burning qualities, and have proved a successful substitute for anthracite.

For further details regarding the operations of the Lignite Utilization Board, the reader is referred to appendix "I" accompanying this report.

10. *Industrial Alcohol.*—The Research Council, as may be gathered from a perusal of the previous reports of the Administrative Chairman, has given attention since its inception to the promotion of measures which should be taken to remove the restrictions imposed on the use of alcohol for industrial purposes, in Canada. On the recommendation of its Associate Committee of Chemists, a special committee was appointed in 1917 to investigate the question and to report its findings to the

Council. This Committee had numerous conferences with representatives of the manufacturers in various lines and of those industries using alcohol in large quantities as a solvent or precipitant, or as raw material from which chemicals could be made, and it found that a number of handicaps were imposed on its use for these purposes which limited its consumption and the development of such industries as depend for their success on cheap alcohol, whether pure or denatured. Those imposed on the use of denatured alcohol arose from the manner in which it was prepared and put on the market and the very limited number of kinds of denatured alcohol allowed. There were pratically only two kinds available and these were prepared at Ottawa and under the control of the Department of Inland Revenue. The distribution of the product to places distant from Ottawa, for example to Halifax or Vancouver, imposed a considerable charge for transportation which increased its cost and thus discouraged its use except in very limited quantities. Further, as only one kind, namely "Methylated Spirits," of a fixed composition was in the main of general use, this restricted its consumption greatly. It was ascertained also that no provision was made for the use of pure tax-free ethyl alcohol in industry except under conditions which of themselves exacted a heavy toll on its use and consequently it was impossible to manufacture in Canada tinctures, essences, extracts, etc., and a considerable line of chemicals to compete successfully with manufacturers of like products in Great Britain and the United States.

The Council on the report of the findings of this Committee made recommendations as to amendments in the Act governing the production of denatured alcohol in Canada and the use of pure ethyl alcohol, tax-free, in certain lines of chemical industry. Of these recommendations the leading ones may be summarized as follows:—

1. That alcohol for general industrial purposes be denatured in premises thereto licensed at various points throughout Canada.
2. That denatured alcohol, used for ordinary purposes, be sold, delivered and transported without restriction to dealers, manufacturers and other persons.
3. That specially denatured alcohol, i.e., alcohol denatured for special purposes for which the ordinary denatured alcohol would not serve, should only be sold or delivered under a special permit to dealers and manufacturers to be used in the arts and industries in cases where ordinary denatured alcohol would be unsuitable.
4. That pure ethyl alcohol (without any denaturant) may be sold free from excise duty and delivered
   (*a*) for scientific purposes, in limited quantities, to Universities and scientific and research laboratories approved by the Minister of Customs and Inland Revenue, and
   (*b*) In limited quantities for the purpose of medical treatment only to public hospitals chiefly maintained by public subscription or endowment, approved by the Minister.

As a result of this movement to free the use of alcohol for industrial purposes from unnecessary restrictions the Government introduced in the Session of 1920 a Bill, No. 178, to amend the Inland Revenue Act, which Bill passed both Houses of Parliament and received Vice Regal assent in June of that year. This Act, however, embodies only some of the recommendations listed above and some of these with qualifications. It allows alcohol to be denatured either for general purposes or with special denaturants for particular uses, not "in premises thereto licensed," *but only in distilleries thereto licensed.* It also provides (Section 267) that "the Governor in Council may from time to time make regulations respecting the sale of spirits to be used for any chemical or manufacturing process not herein otherwise provided for."

So far so much to the good. The Act permits the manufacture of denatured alcohol of any variety, approved by the Department, in any distillery which is

licensed for that purpose, and sold free of excise duty and delivered to the purchasers. the ordinary denatured varieties without any restrictions, the specially denatured varieties only under departmental permit to industries in which ordinary denatured alcohol will not serve. This is an improvement on the former regulations, as it provides extra facilities for obtaining completely denatured alcohol and it gives the Department the power to provide specially denatured alcohols for different industries such as these may require.

So far the Department of Customs and Inland Revenue have allowed two varieties of ordinary or completely denatured alcohol and three of specially denatured, but it is possible that these will be added to in the near future.

The result of the change in the regulations is not all that was desired and it is due to the fact that the denaturing of alcohol is confined to *distilleries thereto licensed instead of in premises thereto licensed.* In consequence the price of ordinary denatured alcohol in Canada at this writing is $1.30 per imperial gallon in barrel lots, while in the United States it is $0.55, also per imperial gallon. This involves a very serious discrimination against Canadian industries using such alcohol in competition with similar American industries.

The use of tax-free pure ethyl alcohol of Canadian origin is not allowed by the Act for use in the scientific and research laboratories of the universities and other public institutions. These can import duty-free such alcohol from abroad without the excise duty of the country of origin and thus they obtain it at a low figure per gallon. If they used Canadian alcohol it would cost them $10.50 per gallon 65 O.P., a prohibitory price. This high price prevents the use of pure ethyl alcohol for bathing purposes in public hospitals in the case of patients for whom such treatment may be prescribed and in consequence ordinary denatured alcohol has sometimes to be used, resulting not rarely in toxic effects on the patients from the vapour of methyl alcohol which may be inhaled during such treatment. It is, however, a matter for satisfaction that the Department is considering the question of allowing under certain conditions the use of tax-free pure ethyl alcohol in hospitals for such cases.

It is in the interest of Canadian industry that the number of varieties of denatured alcohol allowed by the Department of Customs and Inland Revenue should be increased. In this connection it may be pointed out that the Internal Revenue Department of the United States, with a National Prohibition Act that makes it criminal to use alcohol as a beverage, has very greatly increased the number of specially denatured alcohols available to the public, a number that is in utter contrast with the number that is allowed in Canada. It is, therefore, a matter for regret that the Department of Customs and Inland Revenue has not so far permitted the production of a greater number of specially denatured alcohols.

That there may be abuse of this permission does not seem to be indicated by the experience of the Internal Revenue Department of the United States. Mr. James F. Doran, Chief of the Industrial Alcohol and Chemical Division of the United States Internal Revenue Bureau, in a recent address before the National Conventiou of the Anti-Saloon League in Washington stated as follows: "Referring to the use of alcohol in industries since 1906, the amount of alcohol that was denatured increased each year, replacing a certain amount of pure alcohol in commerce, but did not replace an equal volume of alcohol for the reason that new industries were being developed under the stimulus of tax-free alcohol." It may be stated that the regulations governing the use of tax-free, pure ethyl alcohol in the United States and England are not so stringent and complicated as those in force in Canada.

Mr. Doran goes on to say: "The National Prohibition Act changed the outlook very materially and it became apparent that one of the best law-enforcing weapons was the provisiou of the National Prohibition Act providing for more extended denaturation than had hitherto seemed possible under excise laws."

The Inland Revenue Department at Washington has authorized six formulæ for completely denatured alcohol which can be sold under no further restriction than those governing the sale of milk or gasoline, and has authorized also fifty-eight formulæ for specially denatured alcohol for use in a great variety of general industries and hundreds of specific products. There is one formula used in the States more generally than any other, which the Research Council has, through its special committee, strongly recommended to the Department of Customs and Inland Revenue, viz., ethyl alcohol denatured with five per cent of methyl alcohol. This is used in the States as a solvent and as a vehicle for the extraction and preparation of upwards of two hundred pharmaceutical preparations. These cannot be made by Canadian drug manufacturers by the use of the alcohol available in Canada in competition with the American manufacturers. The use of a large number of specially denatured alcohols under Government surveillance should make the inspection of bonded warehouses very much simpler. Specially denatured alcohol is of no use as a beverage and the manufacturers, as well as the Government, are largely relieved of the responsibility incident to handling and storing pure alcohol.

11. *Associate Air Research Committee.*—This Committee, composed of representatives of the Air Board and the Research Council, with a large number of associate members, has been very active during the year, as may be gathered from a perusal of the report of its activities (appendix "H"). It has provided for a number of experimental investigations on problems of immediate interest in aeronautics. In all these it has arranged to avoid duplication of researches undertaken elsewhere, and it has striven to co-operate as far as possible with official research organizations in this line in the United States and Great Britain. The expenses incurred in such investigations have been met by grants from the Air Board which is specially interested in the solution of the problems undertaken, and whose co-operation in this work is appreciated by the Council and the Associate Committee. Attention may be called specially to the final paragraph in the report which refers to the need for further interest in air research work on the part of the public, to the scanty supply of researchers now available, and to the difficulties experienced in the conduct of such research work in Canada due to the lack of facilities for instrument making and precision mechanical work.

12. *The Associate Biological Committee.*—This Committee, which has concerned itself with problems in the chemistry and bacteriology of canned and cured fish and lobster, in 1920 commissioned Principal F. C. Harrison, of Macdonald College, to investigate the causation of the pink or red discoloration which of late years has frequently appeared in green-salted, cured and dried codfish of the Canadian catch of the Atlantic coast. This discoloration, when it occurs in the product, seriously affects its market value and the loss involved, though in instances it may be low, sometimes reaches as high as forty per cent of the producer's output, a figure that is of special significance when taken in conjunction with the fact that the value of these products, the greater part of which is usually exported, in the year ending March 31, 1921, exceeded in value $5,000,000.

This discoloration, although comparatively new to these Canadian products, has occurred at various times and in different countries for the last forty years, and during this period its causation has been investigated with more or less indecisive results. Further, the discoloration, when it did occur, was not such a serious factor in the trade as it is to-day. In the past the cod was smoked, dried and green-salted chiefly in the colder months of the year, the products were immediately thereafter exported and, in consequence, but small quantities of such were affected. Now these products are also prepared and marketed during the warm season of the year and the discoloration has become an important factor in the export trade because its development is promoted at the higher temperatures of that period. Formerly, there-

fore, the problem of the discoloration had little more than a scientific significance. Now it is one of such economic importance as to make it necessary to investigate its causation with the object of finding methods of preventing its occurrence.

Principal Harrison, with whom Miss M. E. Kennedy was associated in this work, gave careful and prolonged attention to the problem, and has reached results which constitute a very considerable advance in our knowledge of the causation of this discoloration. He has found it to be due to a micro-organism to which he has given the name "*Pseudomonas salinaria*," which grows readily in culture media rich in salt and also grows in the sea-water of the tropics and sub-tropics, for he isolated it from samples of brine obtained from Turks Islands (West Indies). It is capable, in different concentrations of solutions of salt, of altering its form, appearing in ordinary sea water as of very minute spherical shape, but when the salinity approaches saturation cylindrical rods are formed between which and the spherical forms all transition stages may be found. The change from the spherical to the cylindrical form of the organism may be brought about by increasing greatly the concentration of salt in the culture medium.

The organism is non-pathogenic, that is, it does not cause disease in animals inoculated with it, nor does it give any injurious effects when the discoloured fish, properly cooked, is eaten.

It occurs in the salt derived by evaporation of sea water of the Mediterranean and the Tropics, in which it draws on the seaweed and other marine vegetable forms of life for the materials necessary for its own growth. It does not occur in the salt derived from mines, such as Liverpool salt, the Windsor (Ontario) salt and the Malagash (Nova Scotia) salt. The occurrence of this organism in the cured codfish from the Atlantic coast of Canada is due to the use of Mediterranean and Tropical salt in place of mined salt. Codfish treated with mined salt does not develop the red discoloration.

Other organisms were isolated from the discoloured fish, and some of them were slightly chromogenic, but none of these played any part, or more than a very subordinate part, in the production of discolouration.

Principal Harrison recommends the resort to a number of measures which will, if constantly put into effect, result always in a product which will be completely free from the organism and the red discolouration it causes. These are:—

1. To use only mined salt in the curing.

If Tropical or Mediterranean salt must be used, it may be sterilized by heating it to 100° C. for half an hour.

2. To clean and disinfect thoroughly all fish curing establishments in which Mediterranean and Tropical salt has been used, this in order to get rid of the organism which otherwise might infect the mined salt used. The disinfection must be thorough and involve all the utensils used.

The findings obtained by Principal Harrison and Miss Kennedy in this investigation must be regarded as of outstanding value in the solution of the problem of the discolouration of fish in the curing of which salt is used.

The report, a comprehensive one, which Principal Harrison has prepared, of the results of this research will, it is very probable, be published by the Research Council for general distribution at an early date.

13. *Fish-curing in Canada.*—In the autumn of 1914 and 1915 the Biological Board of Canada instituted at St. Andrews, New Brunswick, and in connection with the Biological Station there, a series of experimental investigations on the method of curing haddock by salting and smoking to ensure a product which would keep for some time and preserve its flavour and other desirable qualities when marketed in Toronto, Winnipeg, and other centres distant from the Atlantic coast. The experiments concerned the optimum length of time for salting and also for smoking, the length of time in each case determining the keeping capacity of the

product for the market for which it was prepared. Samples of such products were distributed for consumption to a number of centres in order to ascertain their acceptability and reports from those testing them were collected from which data were obtained to indicate the treatment in each case which would give the best product. The results showed that a very decided improvement could be effected in the product destined for each market centre, an improvement that would greatly increase the consumption of cured haddock throughout Canada.

The investigation did not solve all the problems involved and there are still some which it would be advisable to investigate. Nor did the Board undertake at the time any propaganda with the object of inducing the public to call for an improved product, the reason at the time being the lack of funds to meet the expense which might be so incurred. That the investigations and the propaganda may be undertaken some time shortly is a possibility and in view of this any information on the methods used in such curing elsewhere would be of service for reference. In consequence, the Council commissioned Professor J. J. R. Macleod, of the University of Toronto, who was spending a month or so at and near Aberdeen, Scotland, in June and July of 1920, to examine and report on the methods employed in producing the "finnan haddie" which has such a very large market in Great Britain, a task which he performed, to satisfaction, and presented in October of that year a report to the Council which embodied a great deal of information on the subject. This report it was intended to publish in extenso but it was later decided to publish a summary of it in some journal devoted to the fishing interests and it, accordingly, was accepted for the "*Canadian Fisherman*" in which it appeared in the issue of that publication for January, 1921.

There is not the slightest doubt that the consumption of cured haddock in Canada, which is now considerable, could be trebled or quadrupled if standard methods were employed and the public were assured of a product that would be always acceptable. To this end, therefore, further experimental work should be undertaken, not of research, but rather of the empiric kind, to establish such standards in the product for different parts of Canada which would be followed by those engaged in the curing of haddock.

14. *The Administrative Chairmanship.*—When the Council was instituted at the close of 1916 it recommended the appointment by the Government of an administrative officer for the same, to be called the Administrative Chairman. This recommendation the Government accepted and Dr. A. B. Macallum was offered the appointment, which he accepted after some hesitation because he recognized that the position would involve work of the most wearying character but which would have to be undertaken by some one if the Council was to be of effective service in the development of scientific and industrial research in Canada. When he assumed the position it was stipulated by him that it should be for about a couple of years, long enough, he supposed, to organize all the possible lines of activity of the Council. The work proved to be very exacting and onerous, rendered especially so by the fact that a full time Secretary was not appointed to assist. There was for the first two years as Honorary Secretary, Mr. J. B. Challies, Director of the Water Power Branch of the Department of the Interior, who gave as much time to the secretaryship as the duties of his position as Director would permit, of which unselfish service the Administrative Chairman is appreciative.

In 1918 Mr. Leslie R. Thomson was appointed Corresponding Secretary and Mr. Challies' services were retained as honorary Recording Secretary, but in a few months Mr. Thomson resigned to accept the secretarysbip of the Lignite Utilization Board. As the position vacated had just then been classified under the Civil Service and with a low initial salary it was impossible to find a successor to him who would have, amongst other qualifications, the necessary scientific training for the position, and the Chairman had, in consequence, to carry on thenceforward, performing the duties of

two positions, at times almost an intolerable burden. How exacting his task was may be indicated by the fact that in all the four years of his term of service his holidays did not total three weeks.

At the end of the two years which he originally contemplated as the limit of service as Administrative Chairman, Dr. Macallum found that one especially important aim of the Council, the foundation of a National Research Institute for Canada, was still unachieved. He decided, therefore, to carry on still further until that aim was accomplished, and when accordingly in September, 1920, the Council received assurances that legislation would be undertaken to establish the proposed National Research Institute he presented his resignation of the position to the Right Honourable Sir George E. Foster, Chairman of the Sub-Committee of the Privy Council for Scientific and Industrial Research, the resignation to take effect on Octobed 31, and followed this up by accepting the newly created Chair of Biochemistry in McGill University. After November 1 he carried on for over three months as Honorary Administrative Chairman and until Professor R. F. Ruttan was appointed to the position in an honorary capacity.

In June, 1920, in view of the contemplated resignation of Dr. Macallum the Council decided to recommend to the Sub-Committee of the Provy Council that to carry on the administrative work of the Council the position of Chairman should be an honorary one, to be occupied by a member of the Council, and that a very large part of this work should be performed by a Techical Executive Officer who has had a special technical training and also a very considerable experience in the executive line.* The Chairman under this scheme would call and preside at meetings of the Council, bring before it general matters involving measures to promote scientific and industrial work and to represent the Council officially on all occasions when its activities and policy may be concerned. Under this arrangement the work hitherto performed by the Administrative Chairman would be carried on by two officers each with functions which can be performed without too great a sacrifice of their time and energy and therefore with a certain degree of satisfaction to themselves and to the Council.

In this his last report as Administrative Chairman, Dr. Macallum desires to express his grateful appreciation of the courtesy he has experienced throughout the four years from his Colleagues in the Council, from the Members of the Government, a large number of Members of the House of Commons and Senate, and of the leading Government officials with whom he came in contact in his adminstrative capacity.

II. ON THE OVERLAPPING AND DUPLICATION OF EFFORT IN THE SCIENTIFIC AND TECHNICAL WORK IN CANADA

When the Council was constituted in 1916 by Order in Council its duties as laid down therein included the following:—

(*a*) To consult with all responsible bodies and persons in carrying on scientific and industrial research work in Canada with a view to bringing about united effort and mutual co-operation in solving the various problems in industrial research which from time to time present themselves.

(*b*) To co-ordinate as far as possible the work so carried on as to avoid overlapping of effort and to direct the various problems requiring solution into the hands of those whose equipment are best adapted therefor.

There is bound to be, as there is actually, a great deal of overlapping of effort in research in industry. A firm with a great deal of capital at its command, recognizing that the discovery of valuable new processes may result from research, may, in

* This recommendation was accepted by the Sub-Committee in August last and Dr. R. A. Ross was appointed as Honorary Chairman, Professor R. F. Ruttan having resigned the Administrative Chairmanship after six months of service, while Col. F. M. Gaudet was selected to fill the post of Technical Executive Officer.

its provision to this end, cover all the problems of that industry which another firm similarly circumstanced and engaged in the same line of production may undertake independently to solve. The firm that through research discovers and then utilizes new processes which cheapen production or improve its products, or which enable it to utilize cheaper raw material, gains an enormous advantage in the market and even at times can oust competition therefrom. Such a rivalry cannot, and except under special conditions, should not be abated. Industrial firms are, in a free country just as individuals are, entitled to do what they wish with their own funds and their wisdom in the use of such resources may be justified by the results. Rivalry is the law of life in industry, and it is through its operation that manufactured products ever tend to improve in character, increase in output and to become cheaper to the consumers. That much may be gathered from the experience of the past three decades, and it is illustrated to-day in the case of such large industrial organizations as the General Electric Company, the Western Electric Company, the Dupont Company and the Eastman Kodak Company, amongst those of the United States. It is only when the firms or the individual manufacturers have each a very small capital and consequently a small amount to be devoted to research that duplication and overlapping is unwise because it is wasteful. In nearly all the industries of to-day the easily solved problems have been disposed of, that is those which required only small expenditure for their solution. Those that remain or are to be faced if improvement in character and increase in yield of output are to be obtained require for their solution an equipment and a research staff on a larger scale than their resources would permit. For each to attempt on a small scale the solution of such problems may after years give no result justifying the expenditure which may be involved. If one firm or industrialist of limited means undertakes research while the others in the same line do not its or his expenditures may diminish the dividends or profits at the end of the year while there may be no improvement in the character or increase in the yield of the output. If more than one firm or all the firms or individual industrialists in the same line, each with limited resources, provide on a small scale for research, not one useful result may be obtained and consequently firms in that line of industry as a whole may be seriously handicapped in competition with their rivals abroad organized for co-operation in research or which individually engage in large expenditures for this purpose. In such a case the duplication and overlapping of effort in research is wasteful of resources and in the vast majority of instances wholly unjustifiable.

To enable such firms with limited means to engage in research and in the end to benefit from it, the British Research Council began five years ago to advocate the formation in each line of industry in Great Britain of a Trade Association for Research in which all the firms, or a majority of them, in each line would "pool" all their funds available for research on its problems, to be carried on in some large laboratory or plant organized for this purpose. In the case of a Trade Association in which the "pooling" of the funds of its members did not provide an amount sufficient to make certain that the results of the research to be undertaken would be of a character to justify the formation of the association, the Research Council, out of the Parliamentary grant of £1,000,000 voted in 1916, made an annual grant to supplement the amount which resulted from the "pooling." Twenty-four such Trade Associations for Research have been so far established and a number of others are in the process of formation. These will certainly be a factor in determining the success of the industries concerned in the international struggle for trade supremancy. The National Research Council of the United States has followed the lead of the British Research Council and is promoting the establishment in the industries of the United States of similar Associations for Research and a certain amount of success has attended its efforts in this line. The Research Council of Canada has advocated the formation amongst the industries of the Dominion of similar associations

under the name of Guilds for Research. This would provide for effective co-operation in research which would soon put the Canadian industries abreast with, if not in advance of, those abroad which, employing research to the utmost of their resources, aim at conquering the world's market. These Guilds for Research, aided, as occasion and necessity may demand, by close association with the National Research Institute until they can exist alone, would in a few years be a powerful factor in promoting Canadian industrial prosperity, but until the Institute is established not much headway can be made in their formation, for, unassisted by such an organization of highly trained and able scientific experts, they might, except in a few instances, result in failure. The National Research Institute will, therefore, be the keystone of the Guild System and the urgency of its establishment at an early date is not open to question.

The Research Council held that in the rescript of the Order in Council quoted above it was instructed to give attention to the question of duplication and overlapping of effort in the scientific and technical branches of the Government service and its opinion on this point was corroborated by the instructions given to the Council when it was constituted by the Chairman of the Sub-committee of the Privy Council, in which the following were included:—

(*a*) To ascertain and schedule the various agencies in Canada which are now carrying on scientific and industrial research, in the universities and colleges, in the various laboratories of the Government, in business organizations and industries, in scientific associations, or by private or associated investigators.

(*b*) To note and schedule the lines of research or investigation that are being pursued by each such agency, their facilities and equipment therefor, the possibilities of extension, and, particularly, to ascertain the scientific manpower for research available for research and the necessity for adding thereto.

(*c*) To co-ordinate these agencies so as to prevent overlapping of effort, to induce co-operation and team work, and to bring up a community of interest, knowledge and helpfulness between each other.

In the years 1916-1919, two of which were the last of the war period, and the remaining covered the time of readjustment after peace was declared, conditions in the Departments of the Government were more or less unusual as they were for the same reason in the Imperial service and during 1917-1919 in the Federal service at Washington. There were created at Ottawa a number of Boards and Commissions to deal with special problems, not a few of which were technical, relating to the conduct of the war, and unusual duties were imposed on some branches of the Departments which also involved technical work. There was undoubtedly duplication and overlapping in all these activities, yet it was inevitable under the strain of the war; but it was expected that once peace was declared the medley of unusual duplication and overlapping would cease, as in fact it did. There remained the technical and scientific services on the civilian side of the Departments in which, it was currently reported, there was duplication and overlapping but because of the resignation or the detailing of the members of their staffs for military service these services were then more or less in abeyance as it were. In consequence the Council believed that any investigation of the question whether duplication and overlapping in these services might give results which would not obtain during normal conditions and it therefore delayed action on this matter till 1920.

In the meantime the Council regarded it as imperative that it should do nothing that would give even a colour to any accusation of indulging in duplication or overlapping in its own work. Such duplication or overlapping in the work of the Council is impossible because it has no power to carry on scientific or technical work under its own immediate control. As its name implies it is an advisory body—advisory to the Sub-committee of the Privy Council for Scientific and Industrial Research in Canada. It is indeed empowered to give grants for researches on special problems not already

undertaken either in the technical or scientific branches of the Government Departments or elsewhere in Canada, but even these grants have to obtain the approval of the Sub-committee before they are made. Further, it has been the policy of the Council, which it has rigidly observed, not to make a grant for assistance to any research which it considers should be undertaken in the scientific branch of the Department concerned. In one case the Council came to the assistance of a Department. Early in 1917 the Forestry Branch of the Department of the Interior, desiring to initiate investigations on the rate of growth of the more valuable forest trees in Eastern Canada, with the view of determining the conditions which would favour reforestation on a large scale, applied to the Council for a grant to enable it to undertake this research. The Council, knowing that the budget of the Department for that year could not provide the funds required, and recognizing the urgency of the information which such an investigation would give, gave the grant required and repeated it in each of the three succeeding years. At the end of this period, however, it recommend that the Department should make provision in its own budget for carrying on this investigation to its completion, a recommendation which was accepted, and the Forestry Branch is now carrying on the forestry studies on a scale which will, it is believed, be of the very greatest service in initiating a successful system of reforestation which Canada must undertake if one of her largest natural resources is to be maintained undiminished.

It should be noted that in two other instances the Council did recommend that the Government provide for investigations on problems of outstanding importance. One of these was the utilization of the low grade lignites of Western Canada for domestic fuel by the carbonizing-briquetting process. Early in 1917, the Council, after a very careful consideration of the factors involved in this process, and also of the need of some prepared fuel in the West which would take the place of the anthracite imported from Pennsylvania, urged that a grant of $400,000 be made by Parliament to undertake this investigation. This recommendation was not accepted by the Government, but because of the urgent necessity of providing for Manitoba and Saskatchewan an efficient substitute for anthracite, the price per ton of which was then rising there to an almost prohibitive figure, the Administrative Chairman, authorized to do so by the Council, approached the Governments of those two Provinces to induce them to make provision jointly for this experimental investigation. This led to negotiations with the Federal Government on this subject, the result of which was an agreement whereby these Governments undertook to make provision in common for the investigation under a Board known as the Lignite Utilization Board, composed of three members, one representing each of the three Governments, a Board which is now carrying on the experimental work of this investigation in a plant erected for that purpose, near Bienfait, in Saskatchewan. Had it not been for the Council there would have been no attempt made to determine the economic feasibility of the lignite carbonizing-briquetting process. Further, had the Government accepted the original recommendation of the Council it is likely that the experimental work of the investigation would have been carried out by a Board appointed wholly with the approval of the Department of Mines, which from the first desired that this investigation be undertaken and which approved of the Council's original recommendation. As the situation has so far developed the representative of the Dominion Government on the Lignite Utilization Board is a nominee of the Department of Mines.

In the other instance the Council acted in co-operation with the Mines Branch of the same department. In 1919 there was an insistent demand that the peat supply of Eastern Canada should in some measure be utilized as a source of fuel for domestic purposes. In co-operation with the Director of the Branch, Dr. Haanel, who had for several years previously given special attention to peat as a possible domestic fuel, it recommended that an attempt be made to develop commercially the methods for preparing peat for the market, a recommendation which was accepted by the Government and in consequence, and in co-operation with the Ontario Government a Peat

Committee was constituted of representatives of the two Governments, which with the assistance of a technical staff some members of which are members of the staff of the Mines Branch, is now operating a plant at the Alfred bog, from where already a large output of prepared peat has been shipped to, sold and used in Ottawa, Montreal, Peterborough and other centres in Ontario and Quebec. The degree of success which has attended this work may be gathered from the report of Professor Purcell, the technical advisor of the British Peat Board, who examined the work of the plant at Alfred, in which he states that the methods for the exploitation of peat as fuel as employed there are far in advance of those in use elsewhere.

Thus the Council has acted throughout the last four years, avoiding everything that would give rise to even a suspicion of duplication of work or overlapping in research or scientific activities. It may, perhaps, have been over-scrupulous in this, but it is better to err thus than to encourage in the slightest degree any activity which might appear as a duplication of any research carried on in a Government service or in any institution outside it. The funds available anywhere to assist research are all too small and to apply any of them wastefully is, in the opinion of scientific men generally, a crime. Research to-day in many lines, and especially in those involving industrial application, involves long-continued patient efforts on the part of those engaged in it, and therefore, the funds devoted to it should be expended as economically as possible. That is the view which has determined the policy of the Council for the last four years, and it has rigidly observed that policy.

So much for the Council in respect to its own activities in promoting research. There remains the question of duplication and overlapping in the activities in the technical and scientific services of the Government.

As pointed out in the foregoing some of these services were understaffed during the last three years of the war period and in consequence their activities were very considerably curtailed. Duplication, if it had previously obtained, was reduced to a very considerable extent and an investigation of its extent during that time would not have given an indication representative of it as it obtained before 1915 or since 1918. In the two and a half years since the close of the war, however, the services resumed their former activities, inclusive of those which possibly involved duplication and overlapping of effort, and the situation was then such as to make it appear advisable in the public interest, as well as in the interest of the Government Departments concerned, to ascertain the extent and character of this waste of effort. In an attempt made in 1920 to determine the feasibility of the task involved, however, the Administrative Chairman found that any information which might be elicited on the subject through inquiry by the Council, because it would be unofficial, could not be used as the basis of a report thereon that would be authoritative. The Research Council has no inquisitive powers on this score and, accordingly, such information, to be decisive, must be obtained by some one specially appointed to that end by Order in Council, empowered to investigate the technical and scientific services in the various departments and to call before him for examination the chiefs and others of the staffs of those services in order to make an accurate survey of their work and thus to obtain the facts for a report which would be accepted as authoritative.

There the question rests so far as the Council is concerned.

That overlapping and duplication of effort in the scientific and technical services of the Government may, if unchecked, attain a formidable character, may be gathered from what has developed in Government Departments abroad. According to Mr. Adolph Lewisohn, Chairman, and Mr. J. Parke Channing, Vice-Chairman of the New York Committee of the National Public Works Department Association, *twenty-five Federal agencies do mapping work, twenty-seven have authority to build hydraulic works, thirty to make chemical investigations, twenty-two to make engineering researches*, and so on. This, it has been said, is "in miniature the Government system, an absolute want of system, continual overlapping and reduplication and interference, a might maze, and all without a plan!"

III.—THE NATIONAL RESEARCH INSTITUTE

In 1917 the Council, after a full consideration of all the measures which should be taken by the Government to promote scientific and industrial research in Canada, recommended as of the first order of importance the establishment of a National Research Institute for Canada. In the report of the Administrative Chairman for 1917-18 the situation in regard to the provision made for research as compared with that which obtains in the United States, Great Britain, Germany and France was discussed at length and the result was summed up as follows:—

> "In consideration of these facts which are advanced to show the general agreement as to the urgency for each State to provide for organized research by the establishment of Institutes or Bureaus for Research to assist the development of the industries of each, and also because of the special need in Canada of one such, the Research Council has approved of the proposal that a Central Research Institute be established at the earliest possible date, whose functions will be that of carrying on research, not only in pure science in relation to standards of measurement, quality and composition of material, but also in science applied to the industries of Canada."

The report then concludes:—

> "The work of the proposed Institute would powerfully aid the development of scientific research in Canada by stimulating the Canadian Universities to increase their resources and facilities for research, and thereby to direct into the ranks of science the ablest of their young graduates desirous of qualifying for a career, whether in pure science or in science applied to Canadian industry. It would place at the service of Canadian industry a factor which would ensure its success in the strenuous trade competition which is near at hand. It would, above all, enable the nation to direct its energies towards the economic and right utilization of its untouched stores of national wealth in order that it may bear, with some degree of ease, the almost Atlantean financial burden it is assuming as a result of its playing its part in the present world struggle."

In the report of the Administrative Chairman for 1918-19 the urgency of the establishment of the Institute was again pointed out and it was emphasized in the report for 1919-20, in which the following occurs:—

> "The establishment of a National Research Institute which primarily is necessary to promote a great increase in the developed wealth of Canada is, therefore, necessary to the development of the industries of the Dominion and to enable them to hold their own not only in the home markets but also abroad. The urgency of the establishment of this Institute is, therefore, of the first order of importance and every year lost in effecting this establishment will increase the difficulties which Canadian industry will face in competition with industry abroad, aided by all the resources that scientific research will place at its command."

In the session of Parliament for 1919, a special committee appointed to consider the development in Canada of scientific research which was under the chairmanship of Mr. Hume Cronyn, M.P., gave consideration to the measures which should be taken by the government to foster scientific research and it presented to the House on July 2, 1919, a report in which "the establishment of a Bureau of Standards was recommended but while a generous national support for scientific research was unanimously favoured for reasons then stated no decision was reached as to the precise method whereby that support could be most effectively applied."[1] The

[1] Quotation from the report of the Committee for 1920 presented to the House of Commons on April 27 of that year.

Committee recommended that it be reappointed at the next session of Parliament to consider still further and report on the measures which should be taken to promote scientific and industrial research. *The report was, after a debate in which a number of members participated, unanimously adopted by the House.*

The Committee was reappointed in the following session of Parliament with a membership very largely the same as that of the Committee of the preceding year and again under the same chairman. The Committee presented its final report to the House on April 27. *This, after a discussion on it in the House, was also unanimously adopted, the leading representatives of all the parties endorsing it. A copy of this report is given in appendix "G."*

This report urged the establishment of a National Research Institute of the same character as that recommended by the Research Council. To the functions which the Council proposed the Institute should perform the Committee added one: "researches undertaken to promote the utilization of the waste products of the industries." Besides outlining the work which the Institute should undertake the report goes on to recommend:—

> "1. That a National Research Institute for Canada endowed with the functions and of the character indicated in the foregoing, be established in the vicinity of Ottawa, on a site fifty acres in area of easy access and conveniently located for water, gas and electric power supply.
>
> "2. That the first building to be erected for the Institute should be of the best modern construction suitable for laboratory work and of such dimensions as to provide accommodation for some years to come.
>
> "3. That there be appropriated by Parliament $500,000 for the purchase of the site and the construction of the building, $100,000 for the scientific equipment of the Institute, and $50,000 for salaries and maintenance during the first year of its operation.
>
> "4. That legislation he enacted at this session to provide for the establishment of this National Research Institute and the government of the same."

In support of the establishment of a National Research Institute came the unanimous pronouncements thereon from the Canadian Manufacturers' Association, Boards of Trade all over Canada from the Atlantic to the Pacific, Canadian and Kiwanis clubs, and scientific and technical societies, including the Royal Canadian Institute, the Canadian Branch of the Society of Chemical Industry, and so on. The approval voiced by the press was equally unanimous.

The Council after more than three years of effort and hope in regard to the establishment of the Institute had reason, therefore, to believe that it would by legislation be provided for. Unfortunately the government did not take action before the close of the session of 1920, and it was with the Council a case of "hope deferred." In September, however, the Council was assured that the Government would undertake at the ensuing session of Parliament to provide the legislation required, a promise which it implemented by introducing in the session of 1921 a Bill for that purpose, a copy of which is rendered in appendix "I," which Bill with amendments introduced in its passage through the House of Commons received its third reading on May 3, only, however, to fail to receive the approval of the Senate at a later date in the same month.

This is not the place to discuss the action of the Senate on the Bill. Indeed it would be impossible to gather from the debate on it what the attitude of the Senate as a whole was on the principle involved. One thing, however, is clear. It is that the members had not given consideration to the history of the effort to bring about the establishment of the Institute or to reasons which led to that effort being made. The work of the Committee of the House of Commons appointed to consider the best means to promote scientific and industrial research in Canada which resulted after two years of careful consideration of the question in a report, adopted unanimously by the House, urging the establishment of the Institute as recommended by the Research Council for the last four years, had not engaged the attention of the members, and they consequently were not in a position to grasp the purport of the clauses of the Bill. Perhaps it would have been well if the Senate had a committee, like that of the House of Commons, which would have for two consecutive sessions given careful attention to the question, even if there might have resulted "duplication and overlapping" of effort.

The Council, despite this setback, hopes that the establishment of the National Research Institute will be accomplished by legislation at the coming parliamentary session. The Council is an advisory body to the Government and Parliament on all measures which should be taken to promote scientific and industrial research in Canada. Its members are qualified by their training and experience in science to determine what these measures should be. It has urged now for four years the establishment of this Institute.

In the large number of Committees associated with the Council there are one hundred and twenty-nine representative men of science of Canada. Without exception these and the committees which they constitute approve of the recommendation of the Council that a National Research Institute be established.

Elsewhere Research Institutes have been or are being founded. Of those already in operation there are the National Physical Laboratory of Great Britain, the Bureau of Standards, with its Industrial Research Institute, at Washington, the Commonwealth Institute of Science and Industry for Australia, the Cawthron Institute for New Zealand, the National Institute of Japan, the Physikalische-Technische Reichs Anstalt of Charlottenburg, and the Chemical Institute at Dahlem, Germany, and the Research Institute at Brussels for Belgium.

Besides the Central Research Institute at Dehra Dun, India, which is to be enlarged to cover industrial research on a semi-commercial scale, the Government of India has accepted the proposal to found another central Research Institute advanced by the Chemical Services Committee of the Government. Further, the establishment of a Research Institute for Burmah is now under consideration.

The National Physical Laboratory of Great Britain, as its name implies, concerns itself with research in physical, electrical and engineering problems of all kinds and with the standardization of technical instruments and apparatus, of measurements of length, volume, weight, capacity and energy in its different forms. It, however, also undertakes researches on metallurgical problems in co-operation with the Iron and Steel Institute, the Institution of Mechanical Engineers and other technical organizations. It performs a very great service in the development of many technical processes of the industries.

The function of the Bureau of Standards was until 1919 indicated by its name. Since then it has taken on industrial research work. A building of a very large capacity and of the most solid construction, erected in the immediate vicinity of the laboratories of the Bureau and designed for engineering problems for war service, but completed only in November, 1919, was given to the Bureau by President Wilson and is devoted to Industrial Research which will be carried on on a large scale. In it can be located a large number of industrial plants on a semi-commercial scale and some are installed therein already. All these will be engaged on problems of special importance to various lines of industry as the need for the investigation of these arises.

The functions of the Commonwealth Institute of Science and Industry of Australia are:—

(*a*) The initiation and carrying out of scientific researches in connection with, or for the promotion of, primary and secondary industries of the Commonwealth;

(*b*) The establishment and awarding of industrial research studentships and fellowships;

(*c*) The making of grants in aid of pure scientific research;

(*d*) The recognition or establishment of associations of persons engaged in any industry or industries for the purpose of carrying out industrial scientific research and the co-operation with and the making of grants to such associations when recognized or established;

(*e*) The testing and standardization of scientific apparatus and instruments, and of apparatus, machinery, materials and instruments used in industry;

(*f*) The establishment of a Bureau of Information for the collection and dissemination of information relating to scientific and technical matters; and

(*g*) The collection and dissemination of information regarding industrial welfare and questions relating to the improvement of industrial conditions.

The Institute is constituted a body corporate, capable of suing and being sued, with power to hold lands, tenements, goods and any other property for the use of the Institute and to acquire by purchase, gift, grant, bequest or device, any such property for the same purpose. The object is to permit the Institute to acquire from private benefactions funds, and endowments to meet the expenses of the Institute. Further, the appointments to the staff of the Institute are not subject to the control of the Commonwealth Public Service Act (Civil Service Act). The Director is subject to the regulations and direction of the Minister of the Commonwealth Government under whose charge the Institute is placed. This gives a freedom of action for the Institute that could not be had if it were directly under a Government Department.

The National Research Institute of Japan, which is established in the suburbs of Tokyo, has already a large part of the endowment of 10,000,000 Yen which those promoting it aimed at the outset at obtaining, large sums having been given by the Emperor and the Diet. It will function, when complete, as a Bureau of Standards and an Industrial Research Institute for Japan. It is expected that it will be of immense service to the Japanese industries in the competition, which they are now facing, for a place in the markets of the Orient.

In the chief lines of German industry, especially the chemical and metallurgical, research has, during the last forty years, been promoted as it has been nowhere else and, in consequence, Germany had, before the war, won for herself a position in the markets of the world which might readily have become a dominant one had her rulers by their criminal folly not brought about that great catastrophe. Even with the aid of research, however, provided for generously from the capital and earnings of the companies concerned, German industry would not have won such a success had it not been for the service given it by the Physikalische-Technische Reichs Anstalt at Charlottenburg and the Chemical Institute at Dahlem. The former, before the Bureau of Standards and the National Physical Laboratory were established, was practically the Bureau of Standards for the world but it primarily performed for Germany an inestimable service. The latter, staffed with scientific men of pre-eminent research capacity and concerning itself with investigations of fundamental interest in Chemistry as applied to German industry was until ten years ago without a peer outside of Germany.

To repeat, there are in Great Britain, Germany, Belgium, the United States, Australia, New Zealand, India and Japan, National Research Institutes which have played or are certain to play a decisive part in the struggle not only for a place in the markets of the world but also for each nation to maintain a supremacy of its home trade. In Holland and the Dutch colonies there are, and in France, Italy, Finland, and Czecho-Slovakia there are projected, organizations which will provide for each one of these the service of a National Research Institute.

The lesson for Canada is an obvious one. Almost everywhere abroad there is a recognition of the value of scientific research as a factor in the promotion of national prosperity, scientific research, not casually pursued as was the case in the past, but organized and directed to the economic utilization of the natural resources of each

country and to the promotion of human welfare. The day is past when organized society, Micawber-like, waited for something "to turn up" instead of persistently and strenuously directing its efforts to the acquisition of the knowledge that will lessen toil and make life a greater boon than it is to the "dim millions" of the masses.

There must be in Canada an organization, a National Research Institute, in which will centre many of the activities engaged in research with the object of increasing the developed wealth of the Dominion which has been estimated to be something over eighteen billions and less than twenty-five billions of dollars. Under the operation of this Institute properly supported and efficiently organized, there would result an increase in this wealth to perhaps ten times as much in two or three decades. The developed wealth of the United States is estimated to be as much as three hundred billions of dollars.[1]

Canada is less wealthy in natural resources than the United States only in tillable land, coal and water power. The leeway for the development of the wealth of Canada is so great that if this development is achieved in any considerable degree, the debt of the Dominion, $2,350,000,000, and, therefore, now a heavy burden, may become if not a negligible, at least a very light, one on the nation.

In the United States, research, especially in connection with industry, is now being carried on on an enormous scale. There are, it has been claimed, more than 2,000 firms which maintain laboratories specially equipped and staffed to carry on research each in its own line. The Dupont Company, the Western Electric, the General Electric, the Nela Company and a number of other firms spend annually huge amounts to this end. Further, it is estimated that about $30,000,000 will have been spent in 1921 for research of which amount one-third is voted by Federal and State Governments, the remainder being derived from private sources. Research is fostered there as it is nowhere else to-day.

The people, the Parliament, and the Government of Canada cannot be and ought not to be indifferent to this situation. The nation must not be forced in the matter of new knowledge to live on the crumbs that fall from a wealthy neighbour's table. The establishment of a National Research Institute is the first and the earliest measure that should be taken to put Canada in a position to hold her own, to develop her natural resources and thereby to permit a great increase in her population.

This Institute should, as advocated by the Research Council, be under its control, subject of course to the approval of the Sub-Committee of the Privy Council for Scientific and Industrial Research in such matters as the appointments to and the salaries of the staff of the Institute, and the acceptance of grants, donations or bequests given under conditions by private individuals or companies to support special lines of research. The Council should be made a body corporate to administer such and other funds and to acquire and hold property of all kinds necessary for the carrying on of the work of the Institute.

The membership of the Research Council, constituted as the governing body of the Institute, should always consist of representative men of science and some of the leading industrials of the Dominion who would by this membership in the Council be a guarantee to the business, industrial and other producing sections of the nation that the work of the Institute in the line of research would constantly aim at practical results. Without representatives of those sections the Council would indeed in the management of the Institute see to it that its work should be intensely practical, but it would contribute to the success of the Institute for its managing body to have the confidence of the business and industrial classes of the country. To have other interests officially represented in the Council, for instance, those of certain sections of the

[1] The incomes on which taxes were levied in 1918 by the Federal Government at Washington amounted to about $13,400,000,000, but it is believed that if all incomes were included the total would exceed very considerably $20,000,000,000. From this one may infer approximately what is the total of the developed wealth of the United States.

Civil Service, would suggest in the popular mind a tendency to bureaucratic control of the Council or give it a "political complexion" which would impair its usefulness. The National Physical Laboratory of Great Britain is not directly under the control of any Government Department although it receives a large vote annually from Parliament, in some years in the past a sum often in excess of £150,000. It is under the management of a committee of the Royal Society of London. The Australian Institute of Science and Industry is an organization apart from the Commonwealth Civil Service and is subject in the exercise of certain of its functions only to the approval of one of the Commonwealth ministers. The Research Institute of Canada should be wholly free from political control except that exercised as indicated above by a Sub-Committee of the Privy Council. It should be free from even a suspicion of such a control.

Except in the determination of standards, the Institute should not, in the slightest, concern itself with routine work. Standards of the utmost accuracy are used in industrial research and provision must be made for the determination of such in the Institute. Further, not a few of these standards are based on the ultimate properties of matter which, therefore, to be of service must be determined with extreme precision and by methods and apparatus that are not used in ordinary standardization. It would imperil the usefulness of the Institute to do routine work in any other line. The Institute, except in the respect mentioned, should be devoted to research wholly. If routine work were included in its activities, even at first ever so little, it would ever tend to increase and ultimately greatly lessen its research work. The present Food and Drugs Laboratory, the Customs Laboratory, and the Laboratories of the Department of Mines must, therefore, continue to be maintained as they are now as must likewise those under the Department of Agriculture.

That the establishment of a National Research Institution for Canada is of the most pressing importance is the unanimous opinion of the Research Council. It has, let it be repeated, urged this establishment for the past four years. It earnestly urges that legislation should be enacted at the coming session of Parliament to bring about this establishment. The final hour of opportunity has arrived. If it passes unheeded it may be irretrievably lost. It may then fall to sciolists and amateurs to advise as to what should be done to meet the extreme urgency which Canada will face in the next few years. If that should eventuate, then, to paraphrase an ancient utterance: "If it befalleth me as befalleth the fool why should I labour to be more wise"?

In closing this part of his report the Administrative Chairman deems it opportune to place before the readers of it the views on the part which scientific research may play in promoting the welfare of a nation expressed in a portion of an address delivered on April 27, 1921, by the Right Hon. A. J. Balfour, whose sanity of thought and outlook and whose long experience in public affairs give his views on this subject a special value. The occasion for the address was the inaugural meeting of the British Institute of Physics:—

> "The public knows very little about the work which the Council of Industrial Research is carrying on—the public very seldom knows much about the things which most deeply concern it.
>
> "Industrial research is one of the things which most deeply concern the public, and I confess that when I see great industrial disputes going on about the distribution of the results of industry I cannot help thinking. "Why do you not devote half the amount of money involved to increasing the power of man over nature, which would increase the share and increase the total result to be divided among the members of the community, instead of devoting your energies to saying how the relatively petty amount we produce is to be divided among the producers?
>
> "I do not believe that the mere expenditure of money, the mere growth of laboratories, or the mere multiplicity of students is going to produce a larger crop of men of genius, but a large amount of work which does not itself bring to maturity some great discovery is required if great discoveries are to be made.
>
> "I believe that no money is better spent than that devoted to scientific research; no money gives a greater spiritual return; no money is going to have a greater pecuniary return.
>
> "I am often surprised that the imagination of great magnates is not stimulated by the idea that they can really add to the wealth of the whole world by encouraging industrial research. There is nothing selfish about it, and nothing narrow about the results of an increase in physical knowledge.
>
> "What is discovered at the University of Cambridge, of which I happen to be Chancellor, is equally of use in Paris, Chicago, Japan and at the ends of the earth. It is a gift of mankind.
>
> "When I reflect, as I think political economists are rather slow to reflect, on the prodigious changes which discovery has made on the lot of mankind, I am surprised that more is not done by men who do not lack either the spirit of liberality or the means of exercising it.
>
> "I cannot help thinking it is in part due to an imperfect appreciation of the real facts of the case and to the fatal desire to see an immediate result.
>
> "Sometimes an immediate result is obtained, sometimes the discovery lurks undeveloped from the industrial point of view for a generation, but it matters not which—the life of the nation and the life of the community of nations is long, and anything which adds to our knowledge of the physical universe, either in our lifetime or that of our remote descendants, adds something material to the happiness of mankind.
>
> "The hope I have for the world is that by the growth of science invention will give comfort and leisure where at present discomfort and labour are the only means of producing an article and that the people will learn how to use their leisure.
>
> "That is the idea of progress which I think holds out most hope for the future, and that is based on the work of men who are engaged upon probing to the bottom the secrets of nature."

It suffices to add, by way of comment, that the constituted authority of a nation should, as a Government chosen from and by its best, be as appreciative of what industrial research may do to promote national prosperity as Mr. Balfour supposes "great magnates" ought to be.

APPENDIX "A"

REPORT OF THE ASSOCIATE COMMITTEE ON MINING AND METALLURGY FOR THE YEAR 1920-21

The Associate Committee on Mining and Metallurgy during the year devoted its attention chiefly to one of the most important problems which faces Canada at the present time from the standpoint of its economic development, viz, that of the utilization of the deposits of low grade iron found in the Dominion. Notwithstanding diligent research by many persons well qualified for the task, but few bodies of high grade iron ore have hitherto been discovered in the Dominion of Canada. On the other hand, many large bodies of low grade ore are known in localities which are comparatively easy of access.

The development of a large iron industry in Canada, so far as can be seen at present, is therefore dependent on the possibility of the utilization of those great bodies of low grade ore. The difficulty of utilizing such deposits is increased by the

fact that in the adjacent territory of the United States large deposits of high grade ore occur which are easily worked and are now mined on a very large scale. Ores from these deposits are imported very largely into the Dominion of Canada, and the Canadian low-grade ores must be made available at a cost which will enable them to compete with these ores from the United States.

The present time, however, seems to be a very opportune one for a thorough study of the possibilities of the utilization of the low-grade ores of the Dominion, seeing that extensive experiments on the low-grade ores in the Mesba region are now being carried out by large operators in the United States, indicating that they consider the supplies of high-grade ore are threatened with serious depletion.

The Committee has accordingly carried out its work along two lines.

In the first place it has collected all the reports on the iron ore deposits of Canada which have been made by Government surveys, commissions, etc., and has also been given access to a great number of reports on Canadian iron ores made by geologists and engineers to companies and private individuals, which reports are confidential and have never before been made available for public use. Many of these, however, are of great value. The Committee has carefully studied all these reports, with a view to ascertaining whether there are any considerable bodies of iron ore which have not hitherto been carefully examined, and which warrant further study with a view to their eventual exploitation.

In the second place the Committee has arranged to have smelting tests made on a large scale in the case of certain ores which seem to lend themselves most easily to beneficiation. This work has been already commenced and is still under way, but it is not considered advisable at the present time to make any statement concerning the results which have been attained until the investigation has been further advanced and final results secured. It is expected, however, that the investigation will, when completed, be a very important contribution to the final solution of the problem of the utilization of Canadian ores for the establishment of a national iron industry.

APPENDIX "B"

REPORT OF THE ASSOCIATE COMMITTEE ON PHYSICS AND ENGINEERING PHYSICS FOR THE YEAR ENDING MARCH 31, 1921

At a meeting of the Honorary Advisory Council for Scientific and Industrial Research held on December 12 and 13, 1919, it was decided that an Associate Committee on Physics and Engineering Physics should be appointed, to act as a consultative Committee for the Council on problems presented for consideration and solution in these two departments of science, and also to bring to the attention of the Council all matters relating to physics and engineering physics, upon which, in the judgment of the Committee, the Council should take action.

The members of the Committee as constituted, are as follows:—
Professor J. C. McLennan, University of Toronto, Chairman.
Dr. J. S. Plaskett, Dominion Astrophysical Laboratory, Victoria, B.C.;
Professor T. C. Hebb, University of British Columbia;
Professor Frank Allen, University of Manitoba;
Professor R. W. Boyle, University of Alberta;
Mr. H. O. Keay, Grand Mere, P.Q.;
To retire in May, 1922.
Professor A. L. Clark, Queen's University, Kingston;
Mr. Louis Bourgoin, Ecole Polytechnique, Montreal;

Mr. John Patterson, Meteorological Office, Toronto;
Professor H. L. Bronson, Dalhousie University, Halifax;
Professor A. G. McGougan, University of Saskatchewan;
To retire in May, 1923.
Professor L. A. Herdt, McGill University, Montreal;
Professor T. R. Rosebrugh, University of Toronto;
Mr. W. P. Dobson, Hydro Electric Laboratory, Toronto.
Professor A. S. Eve, McGill University, Montreal;
To retire in May, 1924.

Two meetings of the Associate Committee were held during the year, the first on May 21, 1920, in the rooms of the Advisory Council at Ottawa, and the second on January 14 and 15, 1921, in the Physical Laboratory of the University of Toronto.

At these meetings the following matters, among others, came up for discussion:—

1. *National Research Institute.*

At both meetings this subject was considered and discussed. Preliminary sketch plans were presented by the Administrative Chairman of the Council who explained very fully the need for the Institute and the nature of the researches likely to be carried on in it. The subject was fully discussed by all members of the committee and it was finally decided to recommend to the Council that steps should be taken in formulating plans for the Institute to make provision for the erection of (1) a boiler and power-house, (2) workshops, (3) a building containing rooms equipped for carrying on a variety of researches of a scientific and technical nature. In this building temporary provision should be made for the administrative offices.

2. *Scientific Training of University Students in Undergraduate Courses on Physics and Engineering Physics.*

In this connection the Committee were of the opinion that for a perfectly co-ordinated development of industry in Canada, there should be available in addition to the types of scientifically trained men who gradute from our universities at present, a continuous supply of men who, besides possessing good training in mathematics and chemistry, are specialists in physics and engineeirng physics and who have received a training in research work in these two fields. Such men would have scientific knowledge of a character likely to lead them to the discovery of new methods of utilizing our natural resources, and they would also possess a practical knowledge of affairs which would be likely to enable them effectively to put into operation the methods of manufacture which they should devise.

A resolution was passed by the Committee and sent to the president of each University in Canada asking that consideration be given to the establishment of a combined course in physics and engineering physics in each University.

3. *Marine and Naval Research.*

During the Great War a number of the physicists of Canada were engaged under the British Admiralty in developing means of detecting submarines and in devising measures for minimizing the menace with which this type of naval vessel threatened the safety and well-being of the Empire. In the progress of this work it was found that special devices could, if more fully developed, be provided, that would obviate the dangers of collision between ships at sea, that would facilitate the prosecution of hydrographic work, and that would vastly improve navigation in the neighbourhood of rocky coasts, and icebergs, when the areas in which these were located, were covered with fog or were shrouded in darkness.

With a view to making progress in this direction it was recommended by the Committee to the Council that steps should be taken to co-operate with the Department of Marine and Naval Affairs in Canada, in organizing a scheme by which there would be provided a marine station and workshop with a small ship attached for the

investigation of improvements and new methods in sounding, fog signalling, iceberg detection, and all matters connected with navigation in the inland waters of Canada, and in the ocean areas bordering on the Canadian coastline.

4. *Air Research Problems.*

The chairman of the Associate Air Research Committee, Professor Eve, of McGill University, gave an account of the work of his committee, and placed before the Associate Committee on Physics and Engineering Physics, a list of problems in need of solution.

5. *Bursaries, Studentships and Fellowships.*

A good deal of discussion took place in the committee on the advisability of having the grants given for Bursaries, Studentships and Fellowships increased. Owing to the increase in the cost of living and to the necessity of a research student being free from financial worry, it was finally decided to ask the Council to make the grants for Bursaries, Studentships and Fellowships $750, $1,000 and $1,200 to $1,500 respectively, instead of $500, $750, and $1,000.

6. *Institute of Physics.*

Another question which was considered by the Committee was the formation of a branch in Canada of the Institute of Physics of Great Britain. The Committee consider that the chief need of physicists in Canada at present is a Canadian journal that will enable them to publish scientific papers promptly. A sub-committee was appointed to make inquiries as to the probable advantages likely to accrue from the formation in Canada of a branch of the Institute of Physics of Great Britain, and to report its findings to the next meeting of the Committee.

7. *Toronto Conference on Recent Advances in Physics.*

The second meeting of the Associate Committee on Physics and Engineering was held in Toronto in January, 1921, and was coincident with a Conference in Physics which was held at the University of Toronto. By this arrangement it was made possible for the members of the Committee to attend the lectures and take part in the discussions of the conference. Courses of lectures were given by Dr. L. Silberstein on General and Special Relativity and Spectroscopy, by Dr. Irving Langmuir on Atomic Structure, by Professor J. C. McLennan on the Structure of Matter and the Origin and Character of Radiation, and by Professor E. F. Burton on Colloidal Solutions.

8. *Research Problems.*

A number of problems that were presented for solution were laid before the Committee. Among these were:—

(a) *Methods of preventing the deterioration of cement and concrete in Manitoba and the other Western Provinces.*—In regard to this subject it was decided that the arrangements which the Council were making to have the matter investigated by a committee of the Engineering Institute of Canada under the chairmanship of Professor C. J. Mackenzie, of the University of Saskatchewan, were adequate and were such as would likely lead to a satisfactory solution of the problem.

(b) *Earth Temperatures.*—Professor McGougan made a report on the work being carried on in connection with this problem at Saskatoon, and it was decided to recommend that the Advisory Council should urge upon the Meteorological Department of Canada the advisability of gathering information regarding earth temperatures in different localities in summer and winter at various depths.

At the close of the Second Meeting of the Associate Committee on Physics and Engineering Physics it was decided to hold the next meeting at Ottawa while the Royal Society of Canada was in session.

APPENDIX "C"

REPORT OF THE BRITISH COLUMBIA ADVISORY COMMITTEE FOR YEAR ENDING MARCH 31, 1921

During the year 1920-21, the British Columbia Advisory Committee, originally composed of fourteen members, lost a number of these by resignation and departure from local activities. At the request of the chairman, R. F. Hayward, Esq., a Secretary was appointed in February, 1920, to attend to technical and other matters brought before the Committee and to make preliminary surveys of problems in British Columbia which would merit the attention of the Research Council. It was suggested by the Secretary that the Committee as then consituted was too cumbersome and, with the approval of the Chairman of the Council, a small executive committee of three was appointed, to act when required. Messrs. J. M. Turnbull, H. R. MacMillan, and C. McLean Fraser consented to act on this committee.

During the past year the following problems have received attention from the secretary in British Columbia:—

Complex silver-lead-zinc ores,
Iron and steel development,
Utilization of fish offal and non-edible fish,
Wood waste and preservation,
Wood fireproofing.

THE COMPLEX ZINC ORE PROBLEM

This problem has been the subject of very considerable research in many countries and has also been the subject of considerable bounties in British Columbia, with the object of developing a more economic method of treatment than is now possible.

At the request of the Chairman of the Council the Secretary submitted a scheme for research on these ores, and subsequent to approval by the Sub-committee on Mining and Metallurgy, a grant was made for the purpose of carrying on the investigation in the city of Vancouver. A commencement was made on this work in November, 1920, under the personal charge of the Secretary. Valuable information in this direction has already been obtained and the research is still in progress, a report on which will be presented in due course.

IRON AND STEEL DEVELOPMENT IN BRITISH COLUMBIA

There is a very keen desire in British Columbia for the development of an iron and steel industry to utilize the ores, fuels, water powers and labour of the Province. Such a development would have a very far reaching effect upon economic conditions and for this reason it has received the attention of individuals, syndicates, Boards of Trade, the Provincial Government and many other organizations.

The ores of British Columbia are mainly magnetites, often carrying high sulphur and up to 2 per cent copper, existing in the form of large and small deposits widely distributed, on the coast and in the interior.

This ore in its raw state is not suitable for blast furnace operation, as it would be difficult to separate the sulphur and copper so as to produce a good grade of pig-iron.

Furthermore, magnetite is not considered good material for blast furnace operation owing to its refractory nature, necessitating high furnace temperatures which are destructive to brick linings and also requiring a greater consumption of coke, although from a chemical point of view, magnetite, containing less oxygen than hæmatite, requires actually less carbon to remove the oxygen.

A third objection to the blast furnace method exists in the poor quality of the coke available on the coast, which is high in ash and often carries sulphur.

The above technical obstacles, more than lack of market, have prevented development of the industry in the Province.

In order to overcome them it has been proposed to utilize the electric reduction method, with its available high temperatures and using charcoal as the reducing agent. The advocates of the electric reduction furnace do not seem to have realized the necessity for very cheap electric power and for large and cheap supplies of charcoal of a dense nature for the purpose. To reduce a ton of pig-iron requires 2,600 K.W.H. of electric energy costing (at 1½ cents) $39. This is almost the value of the pig-iron laid down on the coast. It does not seem possible to develop electric power in the Province at the extremely low price that this method of reduction calls for. The charcoal which might be made available from mill waste is not well suited for this process as it is too soft to carry the weight of ore in the furnace.

A great deal of investigational work is now being conducted in various parts of the world, on the low temperature reduction of magnetite ores by solid and gaseous reducing agents such as powdered coal and producer gases. It has been well shown that magnetite ores can be reduced in this matter at temperatures far below the fusion points of either the ore, the gangue or the iron itself. The iron remains in the form of a powder.

It appears to the writer that this method offers a solution of the difficulties met with in the development of the industry in British Columbia. The following outline will indicate the advantages to be gained.

The magnetite ore containing sulphur and copper is crushed and subjected to magnetic separation. An iron concentrate is obtained, containing over 60 per cent iron and a very much reduced sulphur and copper content. The copper concentrate contains 20 per cent iron, most of the gangue, and up to 10 per cent copper as well as most of the sulphur. This concentrate would be smelted for copper content.

The iron concentrate is reduced in a rotary kiln with a reducing flame of powdered coal, producing iron in the form of powder, which is subjected to magnetic separation to eliminate the ash of the coal and other impurities. It is then melted down in the electric furnace.

The advantages to be gained from the application of this method to British Columbia conditions would be as follows:—

Sulphur and copper can be largely eliminated by mechanical means and copper values recovered.

Local coals can be used irrespective of ash or sulphur content.

The operation of melting down the iron powder requires only one-tenth the expenditure of electric energy that is required in the electric reduction furnace to produce the same amount of iron, consequently the cost of electric power is not so important.

Magnetite ores can be treated without the addition of hæmatite.

Sulphur and phosphorus can be entirely eliminated in the electric melting furnace at will of the operator, the carbon content can be regulated and almost any grade of pig-iron, steel or alloy can be produced in the same furnace as desired.

Heavy electric installations will not be required.

The plant could be installed in units as required by the market and various products of iron and steel could be made in any unit as required, a very important consideration when opening the industry.

The above and other considerations are of prime importance and should receive the closest attention from those organizations in the Province which are endeavouring to promote the industry.

PRODUCTION OF FISH MEAL AND FISH OILS

In connection with the utilization of fish waste and non-edible fish, the Secretary visited a number of plants during the year. A considerable number of treatment plants have been erected from time to time on the Pacific coast but without any general success. For some years past this industry has been regarded as unprofitable by local banks, which now seldom give support to enterprises of this nature. The causes of failure are several.

The material treated consists of

Salmon offal from canneries,
Halibut offal,
Condemned herring and pilchard,
Dog fish.

Dog fish are caught by Japanese fishermen who usually operate on contract and receive about seven dollars per ton delivered at the reduction plant.

The yield of oil and meal from salmon offal is approximately one ton of meal and eighty (U.S.) gallons of oil per thousand cases of salmon packed. This year British Columbia pack of 400,000 cases therefore is equivalent to 400 tons of meal and 32,000 gallons of oil, worth approximately $30,000 and $10,000 respectively.

The rendering process employed on the coast is often extremely crude from a technical point of view. The raw fish is cooked usually with live steam and with agitation to the state of a thick slurry. It is sometimes allowed to drain before being pressed in hydraulic presses. The liquors are run into settling tanks where the oils separate and are skimmed off. Much oil is lost by the crude methods employed in some plants. The pressed fish is now dried in steam or direct heated driers with agitation. The product is termed fish meal and is graded according to its oil content. It contains up to 15 per cent oil and is then liable to heat up when stored. It commands a market as an ingredient in stock and poultry feed, for which there is a rapidly increasing demand in the Province. The oil from the pressing agitation is sold as body oil to distinguish it from liver oil. When dog fish are treated the livers are separated and rendered separately in steam-jacketed kettles.

In considering this industry and its possibilities for development there will be required:—

A continuous supply of raw material.

A uniform method of treatment for all kinds of raw material, producing uniform products.

A local and reliable demand for those products.

In dealing with the first it is obvious that a large industry could not be built up on salmon offal alone or dogfish alone, although were it possible to use all the raw material available in one and the same plant an industry of some value and providing considerable employment could be established.

It is comparatively easy in the existing type of plant to produce an excellent meal low in oil content from salmon or herring, but difficult to make a meal low in oil from dogfish. It is not easily possible for the existing plants to change the mode of operation with varying shipments of raw material. Furthermore, the oils from these raw materials vary greatly in their qualities and in the prices they command. In order therefore to produce uniform products to conform to the market a considerable change in the processing method will be required.

A meal practicaly free from oil is greatly to be desired and for this reason the writer would favour the solvent extraction process. In order to obtain a reliable market for the oils these should be hydrogenated and made available for soap manufacture on the coast. There is a very considerable market throughout the province for poultry feed. The soap manufactures in Canada for 1920 were valued at sixteen

million dollars and the imports at one and a half millions. The majority of this is laundry soap in the manufacture of which hydrogenated fish oils can be used to advantage.

The hydrogenation process consists in passing hydrogen gas into the heated oil in contact with finely-divided nickel or specially treated nickel turnings. As an alternative the oil may be heated in a nickel lined ball mill containing nickel balls. The mill is revolved while the gas is pumped in through a hollow shaft. The hydrogen gas is absorbed by the oil which when saturated and cooled is in the form of saponifiable fats suitable for soap and other manufactures. The process is a simple one and is very largely employed in Europe and the United States for treating vegetable and fish oils. Its development on the Pacific coast will depend on the development of a reasonably cheap source of hydrogen gas. If oxygen could be utilized in any manner in connection with the refining or treating of these oils both gases could be economicaly generated from water by electrolysis.

In order to process all varieties of raw fish and offal by a uniform method it is suggested that the following general outline be adopted.

The raw material should be cooked with the addition of little or no water in a steam-jacketed vacuum pan with agitation. After sufficient cooking the vacuum is applied and the moisture is extracted leaving an oily sludge containing all of the solids and oils, none of the soluble portions having escaped. Some ammonia would be recovered from condensers attached to the vacuum system.

The moisture-free sludge can now be removed and transferred to an extractor wherein the oil is extracted by a suitable solvent such as gasolene. The writer has produced a meal by this means almost entirely free from oil and without any taint of the solvent by subjecting the meal to a final short heating in vacuum. The solvent can be continuously separated distilled from the oil which remains in a state quite suitable for hydrogenation.

In this matter the maximum yield of meal and oil is obtained and as the operation is conducted throughout in closed vessels, it is free from the usual objections urged against rendering plants.

WOOD WASTE AND PRESERVATION

The wood waste problem of the Province was reported on by the Secretary in the annual report of the chairman for 1920. Since that time no commercial attempts have been made to utilize the waste in any manner.

Attention might very profitably be given to the production of charcoal and wood oils from this waste. If it could be shown that the oils from this waste have a value in the mineral flotation process, they would undoubtedly be produced cheaply.

There is at shingle plants a considerable amount of red cedar waste. Investigation into the insecticidal and germicidal properties of cedar oil as well as its properties as a frothing agent in flotation would be in order. It is possible that cedar oil might be utilized in connection with tarry oils from other mill waste as these possess a value as collecting agents. Cedar wood wool is valued for packing nursery stock for shipment. Cedar oil might have considerable value as a plant spray. It is poisonous. These are matters for research.

In dealing with all classes of mill waste the writer recommends that an attempt be made to carbonize the waste by utilizing an existing mill burner. For this purpose means for restricting the amount of air admitted, and for washing the exit gases so as to collect tar and oils could be provided.

It would also be necessary to provide means for quenching the charcoal produced and for allowing it to dry. As most of the mills concerned are located on waterfront the last points should readily be overcome.

Data on the best values and yields of charcoal and oils from mill waste were given in the report for 1920.

In connection with the treatment of wood for preservation it should be noted that zinc chloride is not as yet used for the purpose in the Province. Creosote is the only preservation used. Should a local manufacture of zinc chloride develop it is highly probable that a considerable export trade would be established to countries with dry climates where chloride treated railroad ties are used.

WOOD FIREPROOFING

An outstanding problem of the shingle industry in the Province was brought to the attention of the Secretary by Mr. F. H. Lamar, of the Shingle Manufacturers' Association of British Columbia.

The cedar shingle manufactures of British Columbia are valued at approximately ten million dollars annually, but this industry is now meeting with severe competition from compounded and so-called fireproof roofings and shingles. Most of these compounded roofings are classified within Class C Fire Underwriters' Association and cedar shingles are not classified. It is believed that but small improvement in the fire resisting properties of the wooden shingles would bring them within the classification.

A very carefully conducted series of tests at the University of Washington has demonstrated that Edge Grain Red Cedar Shingle is quite superior in its fire resisting properties to many of the high-priced prepared roofings that come within the Fire Underwriters' specifications for Class "C". Nevertheless it is highly desirable that a scientific research be made into the treatment of wooden shingles with a view to improving still further their fire resisting properties. Any method developed for the purpose should conform to the following requirements:—

It must be cheap enough to allow competition with compounded roofings.
It must not suffer from, or interfere with, the kiln drying of the shingles.
It must be permanent in effect and weatherproof.
It should not affect undesirably the colour of the shingle or prevent staining of the shingle any desired colour.
It would not be undesirable to treat and stain in one operation.
It should be susceptible of application at the point of manufacture of the shingle, so as to ensure a uniform and standard product.

A variety of substances have been used in various ways for this purpose, but a comprehensive research on the subject would be of great advantage to this industry. Such a research could be conducted within the confines of a small laboratory and combined with advantage with investigation into the by-product possibilities of the red cedar waste of the shingle mills.

CONCLUSION

The above preliminary survey outlines but briefly the more outstanding industrial problems in British Columbia. Each of these problems constitutes a subject for organized scientific research. The solution of these problems would have a very great influence on economic conditions and would provide fields for a great amount of industry and employment.

It is to be regretted that graduates in applied science of the Universities from the Dominion are unable to find employment in their chosen profession within the country and in many cases leave for more profitable fields or abandon their training.

A remedy would be provided in the building of an organization the function of which would be the application of scientific research and discovery to the economic development of the existing industries and the undeveloped resources of the Province.

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APPENDIX "D"

REPORT OF THE PETAWAWA FOREST EXPERIMENT STATION, PETAWAWA MILITARY RESERVE, 1920

Since the last report was submitted, the data collected on the forest survey of the Military Reserve, west of the Canadian Pacific Railway track, have been compiled, and a forest type map of the area has been completed. The types are classified as follows:—

Productive Areas—	*Non-productive Areas*—
White and red pine,	Fields,
Poplar, birch,	Burns,
Jack pine,	Cut over areas,
Balsam, spruce,	Open muskeg,
Spruce bog,	Bog with growth of little value,
Hardwoods,	Flooded areas.
Mixed,	

This series of types is typical of burnt over areas in the range of white pine in Eastern Canada.

As indicated in the last report, the two most extensively distributed types on the reserve are the poplar-birch, and white pine—red pine types. These two types are closely associated, and there are all gradations of mixture from pure pine to pure poplar-birch. This growth appears to have followed fire, that on the main part of the area being about forty-five years old, and that on a smaller area about twenty-five years old. There are considerable areas of jack pine, spruce and balsam and oak and other hardwoods.

As a considerable amount of investigative work on spruce and balsam was in progress during 1920, on cut over pulp lands in Ontario, Quebec and New Brunswick, it was considered advisable to devote the main part of the work at the Petawawa Experiment Station to study of an association of types not being investigated extensively elsewhere. The main part of the work was, therefore, carried on in the white pine-red pine and poplar-birch types.

White pine-red pine type.—There are numerous areas in the white or red pine type scattered over the reserve. While the growing conditions are generally good, one or two large areas show considerable overstocking, and are in need of thinning.

Mixed type, poplar-birch, white pine-red pine.—It appears that, as a general thing, the poplar and birch establish themselves more readily after fire than do the two pines. Where the pine and hardwoods are growing together, the poplar-birch, under certain conditions, gets the upper hand in the early stages and may retard the growth of the pine to a greater or less extent. However, if the pine is once fairly established, it may be expected to grow through the shorter lived hardwoods and eventually reach merchantable size.

Poplar-birch type.—This type is distinguished by the fact that there are practically no pine or other softwoods present. There may be a few isolated well grown pine and some very much suppressed small pine growth; this small growth, however, we cannot expect to reach merchantable size.

The following is a brief outline of the work that has been undertaken during the past year:—

1. Study of the association of poplar-birch type with white and red pine and other softwoods, including a study of the possibilities of increasing the proportion of softwoods and thus improving the general condition of this mixed type of forest.

(*a*) Growth of softwoods mixed with poplar-birch.

Eleven permanent plots have been established in stands in different age classes and in a variety of mixture of the species. In course of time it will be possible to trace the development or mortality of the species represented, and eventually, it is hoped, indicate the conditions of growth under which pine will or will not survive under poplar-birch. This knowledge would assist, in any particular case, in deciding whether it is economic or not to make a release cutting.

(*b*) Experiments in release of softwoods already established, to determine the conditions under which release of this nature will succeed.

Four permanent plots have been established in stands of different variety, and the poplar and birch have been removed; in order to demonstrate the possibility of carrying out an operation of this nature on a commercial basis, the material to be removed was sold on the stump to local residents for fuel wood.

(*c*) Natural regeneration of white pine and other soft woods under poplar-birch, and an attempt at converting a poplar-birch to a soft wood type.

For the attempt at type conversion, an area of four acres was set aside in a thick stand of poplar and white birch, with a scattering of white pine, red pine and spruce. The poplar, birch and other hardwoods have been cut to a diameter limit of 4 inches; this is the first stage in the proposed plan of operation, and, while it is not expected that anything like a pure softwood stand will be the final result of the experiment, it is hoped that there will eventually be the foundation of a stand, in which white pine and other softwoods will play a very much larger part than they did in the original one. An effort has been made to keep the operation on a commercially practicable basis. For that reason it was considered advisable to sell the material on the stump, under suitable regulations, rather than carry out the work ourselves. The timber was sold to local residents, and yielded about $45 per acre. The slash was piled for burning and the work was carried out in a satisfactory manner.

This experiment provides material for study of natural regeneration, and the three permanent plots established in the experiment area, can be combined with four other permanent pots, to form a series of plots for study of natural regeneration of pine and other softwoods under poplar and birch. These seven plots differ from one another in various respects; they differ in density and to a certain extent in composition, and experiments have been made with various methods of treatment.

2. Study of the use of natural methods in restocking areas at present not productive.

Eleven permanent plots have been laid out for this study; the majority of these plots differ from one another in some important respect. In most cases seed trees are available, and an attempt is being made to discover the reasons for absence of young growth. Cultivation by different methods has been carried out on nine of the plots.

3. Study of normal yield of different species and of the factors influencing yield.

One of the first essential for proper management of forest land on a forestry basis, is information as to the amount of timber that will be produced on a given area in a given time. Normal yield tables are intended to represent the growth that may be expected with normal or fully stocked pure stands, and are classified according to the different site qualities. We look to yield tables when we want to forecast the growth of timber we may except on a given area, or when we have to decide on a species to grow or system of management to adopt.

The factors that influence yield are:—

(*a*) Quality of site.

Site quality is a combination of climatic and soil conditions, the physical factors of site. A system of site classification is essential in the preparation and application of yield tables.

(*b*) Degree of stocking.

There is for each species, site quality and age, an optimum degree of stocking. On understocked areas we may expect loss in volume and quality of timber produced; on overstocked areas, also we get loss of volume, owing to the small diameter of the timber grown, and in more extreme cases stagnation of growth may result.

(*c*) Intrusion of other species.

In certain cases this does no harm. In other cases, however, the intrusion of less valuable species has a considerable effect on the volume of merchantable timber produced.

European yield tables are constructed, as a rule, for thinned stands. Thinnings are undertaken with several objects, the main one being to secure the highest yield, in volume and quality, on a given area. Tables based on thinned stands may, therefore, be presumed to represent the best growth possible for the species concerned.

As no thinning practice has yet been developed on this continent, yield tables here are generally based on naturally grown stands, stands that have reproduced themselves by natural means and which have been allowed to grow to maturity without any attempts at improvement. There is no question that stands sufficiently stocked in the first place, and thinned as occasion demands, will produce a higher yield, in volume and quality, than stands originally similar but not so treated.

The following studies have been undertaken at Petawawa on the young white and red pine available. Before any final results are obtained it will be necessary to extend the work to older timber and to a number of different localities within the range of the species.

(*a*) A start has been made in the construction of a yield table. Volume measurements have been taken on twenty-seven (27) sample plots; nineteen (19) of these have been established for periodic examination.

(*b*) Seven (7) plots in the above series of nineteen have been thinned. Thinnings have been carried out by different methods, and a number of plots have been left unthinned in order to provide a comparison between the subsequent growths of thinned and untbinned stands.

The main objects of these experiments in thinning are as under:—

(i) To discover the optimum degree of stocking for each species at different ages and on different site qualities.

(ii) To study the effects of different methods of thinning on the growth of timber and on soil conditions.

(iii) To discover the thinning method or methods best suited to the economic situation in this country.

(*c*) Data have been collected for site classification, in connection with this work. No special studies have been made for this purpose, but a large amount of data becomes available in connection with measurements of volume, and a site classification is being proceeded with as the material accumulates.

4. Study of methods of determining volume of standing timber.

These methods find two main uses:—

(*a*) Estimation of timber for commercial purposes.

The old-time timber cruiser depends on his experience in the woods to tell him how many board feet or how many ties are available on a given area. More modern methods entail some system of selection of sample areas; volumes of these sample areas are determined and the timber on the whole area may then be calculated. The basis of this method is the volume table; this may be in terms of board feet, cubic feet, ties or in terms of any other product. The use of volume tables involves measurement of diameters at a certain height, breast height generally, and may involve measurement or estimation of heights. These tables are based on examination of a large

number of trees and may be prepared with the idea of being general tables for a certain species, or may be made for local use only. It is found that general tables for any given species are not necessarily applicable over the whole range of that species; for this reason local volume tables are prepared and it is found that a local table in one watershed does not necessarily apply to the same species a few miles away.

The volume of a tree is a function of its diameter, height and taper; trees of the same height and diameter but with different tapers, may be expected to have different volumes. Taper may be the main factor causing differences in volume tables generally and is undoubtedly the main reason for differences in volume tables based on diameter and height.

In Sweden it has been found that the main species there, spruce, Scotch pine and larch, each follow the same law of taper and Professor Tor Johnson, of the Royal Forestry College at Stockholm, has developed an easy practical means of classifying trees according to their taper or form. It follows from this, that one volume table prepared on the basis of diameter, height and taper or form-class, can be applied to all of the three main species in Sweden. If it is found that Canadian species submit to the same laws of taper as the species in Sweden, it may be expected that one volume table, prepared on the lines of the Swedish table, can be developed and used for estimation of standing timber in Canada. If it can be shown that the application of these methods is feasible, as it is in Sweden, we would do away to a great extent with the present confusion of general and local volume tables for each species.

(*b*) Accurate determination of volume for scientific work, such as is required in the preparation of yield tables and in studies of the effects of thinning.

The most accurate method of determining volume is to cut and measure all trees. This is possible in a logging operation but not possible in connection with permanent plots established for periodic examination. The methods of determining volume of standing timber commonly used in scientific work involve the cutting and measurement of a number of representative sample trees. This amounts to the preparation of a local volume table for that particular piece of timber. If a permanent plot is established for the study of yield, a repetition of this operation would be necessary at each periodic examination. In connection with sample plot work, particularly permanent sample plot work, there would be a distinct advantage in a method of determining volume of standing timber accurately without cutting trees. It is claimed that the Swedish volume tables already mentioned give a result accurate enough for scientific purposes, and the application of these tables does not involve cutting trees.

From both a commercial and scientific standpoint, therefore, it was considered advisable to continue the work already started at Petawawa on the study of the application of these Swedish tables to Canadian species.

From the results obtained so far, it appears that the Swedish tables apply fairly accurately to white and red pine at the ages represented, forty (40) to sixty (60) years. It appears also that the methods of applying the tables, used in Sweden, might be used for white and red pine with slight modification.

It will be necessary to extend this study to other species and to older timber in different localities within the range of the various species.

In addition to the above work at Petawawa, a start has been made in a study of the reproduction of cut-over pine lands. As there are no operations available for this study at the Experiment Station, it was necessary to secure the co-operation of some lumber company. Messrs. Graves and Bigwood, of Toronto, kindly consented to our carrying on this work on their limits, and a series of five permanent sample plots was established in connection with one of that Company's operations in the Algoma District.

The work planned for the season of 1921 includes the following:—

(1) Continuation of the study of methods of improving the general condition of the mixed poplar-birch and pine type of forest.

Authority has been obtained from the Department of Militia and Defence to cut over 200 acres in this type. Only a small proportion of the timber on this area is merchantable, but the operation will enable us to extend the studies grouped under this head.

(2) Extension of studies of yield to merchantable jack pine and spruce over the reserve, and to merchantable white and red pine in connection with logging operations off the reserve.

(3) Studies of methods of determining volume of standing timber are carried out simultaneously with studies of yield, and these two lines of work will be carried out together.

(4) Studies of the reproduction following logging of pine will be extended to recently cut-over pine lands.

A study of the use of natural methods in re-stocking unproductive areas is dependent on a supply of seed. As last year was a seed year for the main species represented at Petawawa, it is not expected that any of these species will produce seed this year; no plans have therefore been made to extend this work during the coming season.

APPENDIX "E"

FIRST PROGRESS REPORT OF THE ASSOCIATE COMMITTEE ON THE NUTRITIONAL PROBLEMS OF THE FOX INDUSTRY

At its first meeting, on November 15, 1919, the Committee being assured of the co-operation on the one hand of the Health of Animals Branch of the Department of Agriculture, and on the other of the fox breeders of Prince Edward Island, decided to institute a small experimental ranch with attached laboratory, at which, through the agency of a specially appointed resident Biochemist, it might undertake a study of the metabolism and nutritional requirements of the fox.

On December 10, 1919, at the second meeting of the Committee, Mr. G. Ennis Smith was selected to be Biochemist in immediate charge of the experimental work; while Doctors Torrance and Hadwen were appointed to act with the chairman of the Committee as an executive sub-committee dealing with any emergency that might arise during the progress of the research.

Mr. Smith assumed his duties on February 1, 1920, and was instructed in the first place to proceed to Prince Edward Island, establish personal relations with the fox-breeders, and make himself acquainted upon the grounds with the methods and problems of the industry. Upon his return he prepared plans and specifications for the ranch and laboratory, supervised their construction and equipment, and conducted the negotiations which led to the acquisition of the necessary foxes. A report of his activities in these directions, as well as of his visit to Prince Edward Island during the mating season, was received and discussed by the Committee at its third meeting on May 20, 1920.

The experimental ranch was completed on July 8, 1920. Its construction had been made possible only by the co-operation of the Health of Animals Branch of the Department of Agriculture, which provided at its Research Station in Hull, Que., not only the necessary ground-space, but also the pens and kennels for the accommodation of the foxes, and the rooms required for office and laboratory.

The six pairs of foxes with which the ranch was stocked were given to the Research Council, for the purposes of the proposed investigation, by Messrs. Peter G. Clark, Norman McLeod, E. H. Rayner, E. H. Monkley, B. Graham Rogers and George McCallum, all of Summerside, P.E.I. They were received on the very day on which the ranch was finished. The actual work of experiment could be begun therefore about the middle of July.

The first experiments undertaken had for their object the determination of the maintenance ration for the adult fox. The six pairs of animals were placed upon diets, each composed in the main of meat, milk, fox-biscuit, and porridge, but varying in average heat value from 75 to 155 calories per kilogramme per day. The protein content of the diets was also varied, so that while half of the foxes received about 33 per cent of their total calories as protein, the others received about 39 per cent. (It had been intended to make the variation in this respect greater, but the food analysis showed too late that the object in view had not been fully attained.) The different diets were persisted in during the months of August, September and October, a careful record being kept of the weight, behaviour and general appearance of each animal. The results showed that foxes of about ten pounds weight (most of our animals were of this rather small size) can maintain their weight upon a daily ration furnishing 90, but not less than 90, calories per kilogramme. The ration apparently most satisfactory in its general effects was one yielding about 100 calories per kilogram—only a little above the maintenance level. Greater quantities of food than this effected, to say the least, no obvious improvement in the condition of the animals. It may be taken therefore as fairly well established that for adult foxes of about ten pounds weight, a daily ration furnishing 100 calories per kilogramme, of which about a third are derived from protein, meets adequately the energy and protein requirements of the interval between breeding seasons.

As the breeding season approached, the plan of the experiments was changed slightly so as to yield as much information as possible upon (1) the quantity of food required during the periods of pregnancy and lactation, and (2) the possible effects of variations in food suply upon the many factors concerned in the production and rearing of a numerous and healthy progeny. To avoid complicating the problem too much it was thought best to vary deliberately only the supply of protein and of energy; and to compound the diet always of such ingredients that the essentials, such as calcium, phosphorus, and vitamines, were certain to be abundantly supplied. To this end each dietary was so constructed as to include (1) a fairly wide variety of meat products and offal, (2) several kinds of cereals combined in biscuit form with a proportion of edible tankage, (3) milk, (4) eggs, (5) a certain amount of yeast. These ingredients were combined in six different rations. Each of these had practically the same amount of milk and of eggs; but the meat and cereals were so varied in quantity that (1) three of the rations furnished each approximately 100 calories per kilogramme (i.e., little more than a maintenance ration), while the other three furnished between 130 and 140 calories, and (2) within each set of three one had a relatively low, one a medium, and one a relatively high content of protein. Each pair of foxes was then confined to one of these diets (see appendices I and II).

Unfortunately one female (that on the low calorie—low protein diet) died on December 29, 1920. Of the remaining five, two (high calorie—low protein and high calorie—high protein) did not become pregnant. Three females only (low calorie—medium protein—low calorie—high protein, and high calorie—medium protein) produced litters of six, four and five pups respectively. Two of these litters were either still-born, or killed by the parents within a day or two of birth. The one litter raised to maturity was that of four pups produced by the pair on a low-calorie high-protein ration. As the male parent of this litter, as well as the female of the "low-calorie, medium protein" diet, sickened and died at a later date, the first season's work ends with a net increase of one in the total number of foxes.

Such a record is of course on first thought extremely disappointing; yet, as the outcome of an experiment deliberately planned to test the effects of diet, it ought not to be ascribed, without further consideration, to mere ill-luck. It would be equally rash to conclude at this stage of the work that the diets had much, or even anything, to do with the failure of certain pairs to breed, or that of others to raise their offspring; but the possibility that they were effective factors in such directions deserves at least to be further tested. Meanwhile, from the very limited number of

experiments made only one definite deduction is permissible, namely, that the "low-calorie, high-protein" diet is a satisfactory one for the mating season and the period of gestation. The characteristics of that diet are that it furnishes about 100 calories per kilogramme (not much more than a maintenance ration); that approximately half of the calories are supplied by meat products, a quarter by cereals, and the remainder by milk and eggs; and that the meat products include a considerable proportion of offal. The Committee feels that such a diet can be recommended with considerable confidence as suited to the requirements of the pregnant fox.

For several weeks after parturition the mother fox has to meet not only her own requirement, but also, through the provision of milk, that of the rapidly growing litter of pups. Her total requirement therefore increases considerably beyond that of the period of pregnancy. It would be important to determine experimentally just what quantities of food will meet the total requirement at various stages of lactation and for litters of various sizes. As only one nursing mother was available this year no extended series of experiments with this object could be undertaken. The best that could be done was to observe the effect of feeding to the mother throughout the period of lactation, a ration calculated upon a fairly liberal basis. This ration provided during the first week of lactation about 150 calories per kilogramme, and during the second, third and fourth, 180, 220 and 250 calories respectively. The result was excellent. The mother had apparently always plenty of milk, and the four pups (the combined weight of which at birth is estimated at eight ounces) weighed at four weeks of age a total of five pounds.

The problem of the food requirement during the growth period is one which the Committee feels should be given especial consideration, since it is more than probable that certain faults of diet in early life have consequences that can never afterwards be entirely remedied. Unfortunately the number of young foxes raised on the ranch was too small to permit of this problem being attacked in any comprehensive fashion. It seemed best under the circumstances not to place the four pups after weaning on different rations, but to administer to all an identical diet, and to observe its effect upon the entire group. The pups were separated from their mother at nine weeks of age. Their diet for the next four weeks consisted of milk, eggs, fox biscuits, bread, and porridge. The porridge was made of equal parts of whole wheat flour, rolled oats, corn meal and rice, to which were added a little meat, tankage, yeast and salt. The whole ration furnished about 250 calories per kilogramme, of which 100 were contained in the milk and eggs. When the pups were three months old the standard ration was reduced to 225 calories, of which as before 100 were supplied in milk and eggs, but only 75 as cereals, while meat was now included to the extent of 50 calories. Under this regime each of the four pups has shown very satisfactory growth, with no sign of rickets or other nutritional disorder. At five months of age they were all bigger and heavier than either of their parents. Although the sire was a woolly fox with fur of a pronounced brown shade, none of his offspring shows these undesirable characteristics. All have fur of good silky lustre, and clear jet-black colour. Even when compared with their dam they are better-looking, and probably more valuable animals.

It cannot be claimed as yet that diet was responsible, either wholly or in part, for the apparent improvement of breed here reported. If it was, the diet of the mother fox during pregnancy had probably nearly as much to do with the result as that of the pups themselves. But it may at least be said that the diet chosen for the pups permitted the development of such good qualities as they may have inherited, and brought them to maturity in an excellent state of nutrition. Whether it represents from every point of view an optimum ration is rather unlikely, and must in any case be tested by more extensive experiments.

The problems of the maintenance requirement, and of the special requirements of pregnancy, lactation and growth are all which it has been possible as yet to attack by direct experiment; and for most of these problems only a partial solution has yet

been found. Nevertheless, as the experiments proceeded, a number of incidental observations have been made bearing upon other questions, such as, for example, the possible influence of diet upon the abundance and quality of the fur. Data upon this and other matters of practical importance are steadily accumulating, but the Committee feels that it is too early even to attempt to estimate their significance.

In conducting the investigations here briefly reported the Committee has been greatly encouraged from time to time by evidences of the interest taken in its work by those actually engaged in the business of fox breeding. This has been shown not only by the demand for the Research Council's Bulletin (No. 8) already published, but also by many inquiries reaching both the Chairman and the Biochemist in charge, and by visits paid by individuals and deputations to the experimental ranch. In view of this interest the Committee decided at the fourth meeting on October 8, 1921, to have Mr. Smith prepare for publication a bulletin reporting, in non-technical language, the conclusions already arrived at. At this meeting it was also decided that, if funds were made available, the experiments carried out in 1921, should be repeated upon a larger scale. It was felt that in no other way would it be possible to decide how far the actual outcome of the season's work was attributable to dietary factors.

The Committee regrets to record the loss of two of its original members—Professor John Tait by resignation, and Dr. Seymour Hadwen by departure from Canada. In their place Dr. E. A. Watson has been appointed a member both of the Associate Committee and of its executive sub-committee.

Exhibit 1 of Appendix E

Daily Rations per pair during Breeding and Gestation Periods.

Description of Diet	Low Calorie			High Calorie		
	Low Protein	Medium Protein	High Protein	Low Protein	Medium Protein	High Protein
Number of diet	13	14	15	16	17	18
Weight of pair, lbs.	20	23	21	22½	19½	19½
Cereals, ½ oz.	4½	3½	2	7½	4½	3½
Meat, oz.	6½	11	13½	9	12½	16
Milk, fl. oz.	10½	12	11½	12	10½	10½
Eggs	1	1	1	1	1	1
Cereals, calories	405	346	190	718	468	360
Meat, calories	225	388	475	328	450	558
Milk and eggs, calories	270	315	285	307	270	270
Total calories	900	1,049	950	1,353	1,188	1,188
Protein, calories	237	340	359	340	377	422
Nitrogen, gms.	9·3	13·3	14·0	13·3	14·7	16·

½ or, alternatively, a caloric equivalent to fat.

Exhibit 2 of Appendix E

Average Actual Consumption per Kilogram per Day during Breeding and Gestation Periods.

No. of Diet	Total Calories	Protein Calories		Gms. Nitrogen
		Actual	% of Total	
13	103	27·1	26·3	1·06
14	102	33·0	32·4	1·29
15	103	38·9	37·8	1·52
16	132	33·3	25·2	1·30
17	134	42·5	31·7	1·66
18	137	48·6	35·5	1·90

APPENDIX "F"

REPORT OF THE COMMITTEE OF THE HOUSE OF COMMONS, APPOINTED TO CONSIDER THE MATTER OF THE DEVELOPMENT IN CANADA OF SCIENTIFIC RESEARCH, PRESENTED TO THE HOUSE OF COMMONS ON APRIL 27, 1920.

The special Committee appointed last year to consider the above question presented their report thereon to this House on the 2nd day of July, 1919. In that report the establishment of a Bureau of Standards was recommended, but while a generous national support for scientific research was unanimously favoured, for the reasons then stated no decision was reached as to the precise method whereby that support could be most effectively applied.

Your Committee, the majority of whom served in a similar capacity last year, having further considered the whole matter in the light of the evidence and material already adduced have no hesitation in stating that the urgency of action to be taken to establish a National Research Institute to promote scientific and industrial research in Canada is patent to all who know what is being done abroad in this line.

There is in Canada no organization which even distantly approaches the character of any of the Research Institutes abroad or now being establishe.

Great Britain has the National Physical Laboratory at Teddington, near London. Germany has two Research Institutes, one Physical and the other Chemical. In France and Italy measures are being taken to organize Research Institutes. The United States has a National Bureau of Standards at Washington, to which is now attached a laboratory building of exceedingly ample accommodation to be devoted to industrial research. The amount spent by the Bureau exceeds two million dollars a year. The Commonwealth Government of Australia is establishing an Institute of Science and Industry. An Institute for Research known as the Cawthorn Institute is being established at Nelson, New Zealand, by private benefaction. Japan is founding a National Research Institute, for which already ample funds have been obtained from the Emperor, the Government and from private sources.

It is evident, therefore, that Canada, to meet the international competition which the work of these laboratories will serve to accentuate very greatly, must have a National Research Institute, which will place at the command of the country all the resources of Science and further the development of the natural wealth of the country to meet the huge burden of debt imposed by the war. The developed wealth of Canada as compared with that of the United States is small. If the natural resources of the Dominion were appropriately utilized, its developed wealth might readily be as much as ten times what it is now. The conversion of our natural resources into developed wealth, however, can only be accomplished through the application to them of science of the most highly advanced type.

To take one instance only, to show how vital research is to Canada, it may be pointed out that the high grade iron ores of the world are being exhausted, and, in consequence, the lower grades must in the very near future be alone available. Of these Canada has an enormous supply in areas distributed from the Atlantic to the Pacific. We are to-day importing annually at least $150,000,000 worth of ore, iron, steel and their products. If research could show us how to utilize commercially our own low grade iron ores in competition with foreign high grade ores we would not only build up important mining and manufacturing industries throughout Canada, but as well avoid remitting vast sums abroad.

It may be pointed out also, that in Great Britain the industrial firms in a large number of lines of industry are now being organized under the auspices of the Department of Scientific and Industrial Research into Trade Associations for Research. These industries will thereby be put in a position of enormous advantage as regards production. The National Research Council of the United States is organizing similar associations in the United States to meet competition from abroad. In Canada the

organization of similar bodies, "Guilds for Research," must be encouraged by being associated with a National Research Institute.

Your Committee believe the first step towards providing for the research required is the establishment of a National Research Institute whose functions will be to carry on researches, not only parallel to those of the Bureau of Standards at Washington, but such also as will assist in the development of the natural resources of the country and will promote the application of the most advanced scientific knowledge to all lines of industrial production in Canada.

In this connection your committee have considered the following matters:—

1. The scope of the work of the proposed Research Institute and the form of its government.

2. The site of the Institute and the character of the buildings which should first be erected.

3. The appropriation that should be made by Parliament during this session for the purchase of a site. The erection of the buildings and the maintenance of the Institute.

1. The work of the Institute should include the following:—

(*a*) The investigation and determination of standards and methods of measurements including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter.

(*b*) The standardization of the scientific and technical apparatus and instruments for government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service.

(*c*) The investigation and standardization upon request of the materials which are or may be used in the industries, and of the products thereof.

(*d*) Researches undertaken with the object of improving the technical processes and methods used in the industries and of discovering new processes and methods which may promote the expansion of the existing industries or the development of new Canadian industries.

(*e*) Researches undertaken to assist in the development of the natural resources of Canada.

(*f*) Researches undertaken to promote the utilization of the waste products of industries.

2. The Institute should have charge, direction or supervision under conditions to be determined in each case of the researches which may be undertaken by or for individuals or industrial firms or by such organizations, to be known as Trade Guilds for Research, as may desire to avail themselves of the facilities offered for this purpose by the Institute.

Your Committee strongly recommend:—

1. That a National Research Institute for Canada endowed with the functions and of the character indicated in the foregoing be established in the vicinity of Ottawa, on a site fifty acres in area, of easy access and conveniently located for water, gas and electric power supply.

2. That the first building to be erected for the Institute should be of the best modern construction suitable for laboratory work and of such dimensions as to provide accommodation for some years to come.

3. That there be appropriated by Parliament $500,000 for the purchase of the site and the construction of the building, $100,000 for the scientific equipment of the Institute, and $50,000 for salaries and maintenance during the first year of its operation.

4. That legislation be enacted at this session to provide for the establishment of this National Research Institute and the government of the same.

APPENDIX "G"

REPORT OF THE WORK OF THE ASSOCIATE AIR RESEARCH COMMITTEE FOR THE YEAR ENDING MARCH 31, 1921

During the year seven meetings of the Associate Air Research Committee were held—April 17, May 18, July 8, October 9, October 23, November 27, January 18, 1921.

The work of the Committee has been carried on as far as possible in consultation and co-operation with other committees on aeronautical research. Communication has been maintained with the Director of Research, Air Ministry, London; Aeronautical Research Committee, Teddington; the various Departments of the Dominion Government, including the Air Board, Department of the Interior, and the Dominion Meteorological Service. The Committee has been in correspondence with the National Advisory Committee for Aeronautics, Washington, and the Bureau of Standards, endeavour being made in every case to avoid duplication of work and to interchange information as far as possible. The relations with the Technical Department of the Air Board have been especially close, and it is to be noted that the funds for research have hitherto been provided exclusively by the Air Board.

In September, 1920, the Chairman of the Committee, Dr. Eve, paid a visit to Washington, and had the fullest opportunity of becoming acquainted with the aeronautical research work in progress in the United States. Experimental work on the following, among many others, was being carried out:—

Wind channel work, including experiments on the resistance of the velocity of falling bombs;

Investigations on aeronautical instruments, including compasses, altimeters, drift indicators, wireless direction finding;

Investigations on the cause of statics in radio work, determination of the inclination of an aeroplane with regard to the vertical;

Photographic survey work from an aeroplane, the method adopted at the Bureau of Standards being to use a triple camera having a centre plate horizontal and two side plates making an angle of 30 degrees with the horizontal. In this way a strip of country six or seven miles in width can be covered.

Dr. Eve was particularly impressed with the desirability of confining our aeronautical research work in Canada to problems which naturally arise in Canada, not attempting in any way to compete in general research with countries having enormously greater experimental and monetary facilities. It may be added that the Committee has steadily followed this policy.

Dr. Eve was also impressed with the difficulty experienced in the United States, as elsewhere, owing to the dearth not only of trained research workers but also of skilled mechanics competent to develop and construct the necessary apparatus. This matter has been discussed at several meetings of the Associate Air Research Committee but so far no means of getting over the difficulty has been discovered. It is hoped that the establishment of the proposed Research Institute will enable some progress to be made in this matter.

Dr. Eve received the heartiest welcome in Washington and was permitted to see everything without reservation.

During the summer of 1920, Dr. Batho proceeded to England and continued his work at the Royal Aircraft Establishment, Farnborough, furnishing an interesting report of his observations on his return. His report deals with the work then in progress in England, for example, full scale experiments, wind channel work, stability studies, slip stream investigations, wing forms, stalling angles and speeds, air screw

experiments, aeronautical instruments, automatic control of aeroplanes, problems relating to the structural strength of aeroplanes, fire prevention, torque reaction from engines, supercharging and other engine problems.

During the year the Committee has been furnished with copies of R. & M. from Teddington; with the reports of the United States National Advisory Committee for Aeronautics, with the Progress Reports of the Air Board and other current documents regarding research.

Sir Richard Glazebrook has kindly consented to act as the British corresponding member of the Committee, and Dr. McLennan, during his visit to England in the summer of 1920, was also good enough to act as our representative.

At the fifth meeting of the Committee, a sub-committee on Radio Research Work was appointed, the members being Dr. Eve, Professor King, Commander Edwards, Professor Rosebrugh, and Mr. F. C. Higgins of the Air Board. Questions regarding proposed researches in connection with radio work are to be referred to this sub-committee.

As regards the general work of the Committee, the following subjects were dealt with during the year:—

EFFECT OF CLIMATIC CONDITIONS ON DOPE AND AEROPLANE FABRIC

After some preliminary enquiry, it was decided that as no special difficulty has as yet manfested itself owing to Canadian climatic conditions, investigations on this matter are not at present necessary.

VISUAL RECEPTION OF RADIO SIGNALS

This subject has been brought to the attention of the Committee on several occasions and preliminary enquiries as to work carried on elsewhere have been made but it does not appear that the facilities at the command of the A. A. R. Committee are sufficient to warrant embarking on this research.

LANDING GEAR FOR WINTER FLYING

This subject is of considerable interest to Canadian air men and some progress has already been made by the Air Board in the development of suitable winter landing gear. The committee has had under consideration an experimental programme designed to assist in this work.

STRAYS OR ATMOSPHERICS IN RADIO WORK

This question was brought up by the Chairman in October, 1920, and the Committee has endeavoured to enlist the services of a number of observers in different parts of Canada whose simultaneous observations would tend to throw light upon the origin of these disturbances. Very little progress, however, has been made in this respect.

TESTS OF AERONAUTICAL INSTRUMENTS AT LOW TEMPERATURES

A suggestion from the Topographical Surveys Branch, Department of the Interior, with regard to the provision of the necessary equipment for experimental work on this subject was received in October, 1920, and an estimate was made of the cost of the necessary apparatus. In view of the fact, however, that work of this kind is being actively carried out elsewhere it was not felt that the expenditure was justified and the special equipment necessary was therefore not provided.

OPERATION OF CARBURETTORS AT LOW TEMPERATURES

Professor Angus, Department of Mechanical Engineering, University of Toronto, has undertaken a series of experiments with a view of finding out how to avoid

certain difficulties arising in the operation of aero engine carburettors at low temperatures, and a grant of $3,000 for this work was voted by the Air Board in November, 1920. Considerable delay, however, has been experienced in obtaining the necessary apparatus and equipment and little progress has been made during the year.

OPERATION OF AERO ENGINES AT LOW TEMPERATURES

Owing to the favourable climatic conditions existing at Edmonton, Professor Robb, of the University of Alberta, was asked to undertake a series of experiments intended, especially, to develop the necessary technique for starting aero engines which have been exposed to extremely low temperatures, and a grant of $1,000 was made for this work by the Air Board in November, 1920, the Board also furnishing for the purposes of the experiments a Liberty 12 engine and propellor and the necessary subsidiary apparatus. The services of a suitable mechanic have been obtained and the work has been actively prosecuted with very encouraging results.

ANTI-FREEZE MIXTURES

Work on these materials has been carried out by Professor McKergow, Department of Mechanical Engineering, McGill University, a grant of $200 having been voted by the Air Board for the work. These experiments cover the determination of the freezing and boiling points of various commercial anti-freeze mixtures, the investigation of the changes which take place in them during evaporation, and an enquiry as to the injurious effect, if any, which they have on the pumps, radiators, and connections through which they pass. A preliminary report was made in March, 1921, and the investigations are being continued, the information already furnished having proved of considerable value to the officers of the Air Board.

EFFECT OF LONG STORAGE ON LUBRICATING OIL

This question was considered by the Committee in January, 1921, and arrangements are being made for an investigation with a view of determining the changes, if any, which take place in various lubricating oils suitable for aero engine purposes when these oils are stored for considerable periods at low temperatures. This question is of importance as considerable quantities of such materials are necessarily stored for long periods at various points in the Northwest so as to be available for use if needed.

EFFECT OF CLIMATIC CONDITIONS AND STORAGE UPON THE WOODEN MEMBERS OF AEROPLANE STRUCTURES

Long continued storage of aeroplanes built during the war has been found to affect the wooden members of the fuselage, wings, etc., considerably, owing to the effect of drying out and changes in humidity. An investigation regarding this has been carried out under the auspices of the Committee by the Forest Products Laboratories and the interesting results obtained were embodied in a report to the Air Board.

USE OF QUARTZ FOR BAROGRAPH DIAPHRAGMS

Mr. Stanley Smith, University of Alberta, has undertaken a research with a view of finding whether quartz is a suitable material for barograph diaphragms and whether its employment will avoid the difficulties due to lag and hysteresis which are so prominent in barographs of ordinary construction. A grant of $500 has been made by the Air Board for this work. A similar problem is being dealt with in a different manner by Mr. W. C. Way, of the Surveys Laboratories, Department of the Interior. Mr. Way, with the permission of Dr. Deville, the Surveyor General, is endeavouring to develop a novel form of barograph construction which will eliminate the difficulties above referred to, and has obtained encouraging results.

WIND CHANNEL WORK

A considerable amount of wind channel work has been carried out by Professor J. H. Parkin at the University of Toronto, but no grants have so far been applied for in connection with his investigations. His work has dealt chiefly with the calibration of the wind channel and its equipment and with an investigation on the effect of variation of plan form of wing tips on efficiency, the results having been published as a Research Bulletin by the University of Toronto.

The amount actually expended by the Associate Air Research Committee on account of grants up to March 31, 1921, is $450.

The Committee continues to feel very strongly the need for further interest in air research work on the part of the scientific public, and constant efforts have been made to add to the somewhat scanty list of researchers at present available. The committee would also draw attention to the difficulties arising in connection with research work in Canada owing to the lack of facilities for instrument making and precision mechanical work.

APPENDIX "H"

THIRD SPECIAL REPORT ON THE OPERATIONS OF THE LIGNITE UTILIZATION BOARD, FROM JUNE 1, 1920 TO OCTOBER 31, 1921

The Lignite Utilization Board of Canada was created during the summer of 1918 by Dominion Order in Council. In its relation to business interests, it has the general power of an incorporated company, and in relation to the Governments of the Dominion of Canada, the Province of Manitoba and the Province of Saskatchewan it acts as a trustee.

The personnel of the Board is as follows:—

R. A. Ross, D.Sc., E.E., M.E.I.C., Chairman;
Representing the Dominion of Canada.
J. M. Leamy, Esq., M.E.I.C.,
Representing the Province of Manitoba.
The Honourable J. A. Sheppard, Moosejaw;
Representing the Province of Saskatchewan.

The history of the formation of the Lignite Board, its relation to the Research Council, and a general review of the work carried on from October 1, 1918, to May 31, 1920, are covered succinctly in appendices "E" appearing in the annual reports of the Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research for the years 1918-19 and 1919-20. It therefore seems inadvisable to repeat such information in this report.

At the close of the period covered by the last report the Board stated that the construction contracts had just been awarded for plant buildings, briquetting machinery, power equipment, conveyers, etc.

At to-day's date the Board can report that the construction of its plant is completed. Appended hereto is a diagrammatic perspective showing the general appearances of the plant. With this perspective is a plot drawing showing the arrangement of all the buildings, which layout also illustrates the routing of the material through the plant.

The initiation of production at any new plant is always attended by certain difficulties and trials. New machinery is rarely in a position to operate immediately up to capacity, and small errors and weaknesses must be discovered by trial operation

and corrected before capacity operation can be attained. It is the intention of the Board to get each department of the plant under operation separately and then to attempt a continuous through-put.

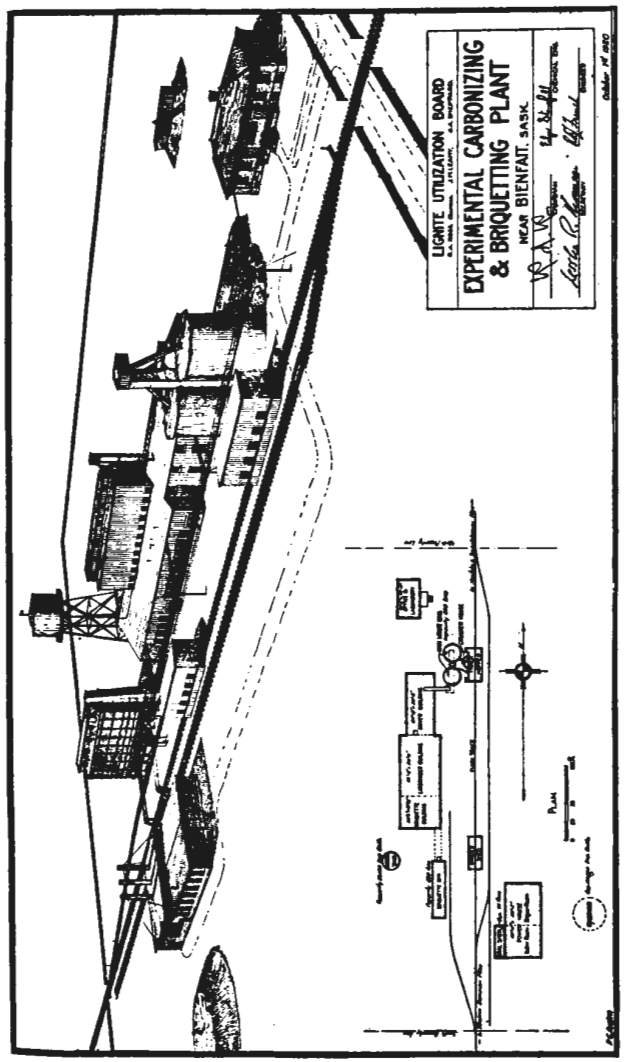
When in addition to the difficulties of starting production with standard apparatus is added the difficulty of initiating entirely new processes, the size of the task before the Lignite Board can be appreciated. At date of writing, the power equipment, the conveyer systems, the dryers and the briquetting machinery have been tested and placed under operation, with, on the whole, successful results. The new carbonizers, of novel design, to which reference has been made in previous reports, have been operated once or twice and have developed minor defects which are confined entirely to auxiliary equipment. Nothing has occurred that cannot be corrected by comparatively unimportant changes, and the Board is still engaged in conducting continuous trials of the carbonizers.

The remaining equipment of the plant calls for no special comment in such a report as this. All the machines are standard, and are such as may be found in any ordinary power plant. The detailed information in connection with these matters will be submitted to the Governments in a complete report at the termination of the work.

The question of the cost of the finished briquettes is one that deserves a word or two. At present the Board proposes to place the briquettes on the market through two distributing agencies, one for the Province of Saskatchewan and one for the Province of Manitoba. The price of these distributors will be in the neighbourhood of $12.50 per short ton of briquettes, f.o.b. plant, and the price to the consumer will be this figure plus freight plus dealers' handling charges.

In order to familiarize the public with the use of carbonized lignite briquettes, the Board has prepared a special memorandum to be distributed very widely, outlining the best methods of firing the briquettes, and giving a certain amount of elementary information on the theory of combustion. Carbonized lignite briquettes, while possessing almost the same heating value as the market grades of American anthracite, possess very different burning qualities, and therefore must be fired in domestic furnaces in a different manner. Copies of this instruction sheet can be obtained on application to the Board's office, Montreal, or to the Souris Coal Sales Company, of Winnipeg, or to the Skingle Coal Company, Moosejaw.

In closing, the Board wishes to record its appreciation of the continued co-operation of the Mines Branch, Department of Mines, Ottawa.



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APPENDIX "I"

COPY OF BILL ENTITLED "AN ACT TO AMEND THE RESEARCH COUNCIL ACT AND TO ESTABLISH A NATIONAL RESEARCH INSTITUTE" INTRODUCED IN THE HOUSE OF COMMONS, APRIL 8TH, 1921.

His Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

1. *The Research Council Act*, chapter twenty of the statutes of 1917, is amended as follows:—

Membership of Council increased.

(*a*) By substituting the word "fifteen" for the word "eleven" in the first line of section three thereof.

(*b*) By adding the following section immediately after section eleven of the said Act:—

Council Incorporated.

"12. The Council is hereby constituted a body corporate capable of suing and being sued, of holding lands, tenements, hereditaments, goods, chattels and any other property movable or immovable, for the purpose of and subject to this Act. It shall have power to acquire by gift, grant, bequest or otherwise any such real estate, property money, or securities for the purposes of this Act, and, subject to the approval of the Sub-Committee, to agree to any conditions upon which such gifts, grants or bequests may have been made. The said Council shall have power to appoint such officers, clerks and employees as may be necessary for the conduct of its business, and, subject to the approval of the Sub-Committee to prescribe the remuneration to be paid the same."

2. The said Act is amended by adding thereto the following as Part II thereof:—

PART II

"NATIONAL RESEARCH INSTITUTE"

Institute created.

"13. (1) There shall be established within the Dominion of Canada a National Research Institute, hereinafter called the "Institute," which shall consist of a Director and such scientific and technical and other officers, clerks and employees as may be necessary for carrying on the work of the Institute. Subject to the approval of the Sub-Committee, the Director and other officers, clerks and employees shall be appointed by the Council, which shall also prescribe their several duties, remuneration and tenure of office.

Powers of Director.

"(2) The control and direction of the work of the Institute shall be exercised by the Council through the Director, or, in case of illness, suspension or absence of the Director, or in case of a vacancy in the office of Director, through an acting Director temporarily appointed by the Council.

Director to give his whole time to work, to report, etc.

"(3) The Director shall devote the whole of his time to his duties as Director of the Institute in its various departments, and shall report to the Council on the work of the Institute from time to time or when called upon to do so. He shall have the right to

be present and to take part in the discussions, but without the right to vote, at all meetings of the Council while matters affecting the work of the Institute may be under consideration.

"14. (1) The Institute shall have charge of— Duties of Institute.

"(a) Researches undertaken to promote the utilization of the natural resources of Canada;

"(b) Researches undertaken with the object of improving the technical processes and methods used in the industries of Canada, and of discovering new processes and methods which may promote the expansion of existing or the development of new industries;

"(c) Researches undertaken with the view of utilizing the waste products of said industries;

"(d) The investigation and determination of standards and methods of measurements, including length, volume, weight, mass, capacity, time and heat, light, electricity, magnetism and other forms of energy; and the determination of physical constants and the fundamental properties of matter;

"(e) The standardization of the scientific and technical apparatus and instruments for the Government service and for use in the industries of Canada; and the determination of the standards of quality of the materials used in the construction of public works and of the supplies used in the various branches of the Government service;

"(f) The investigation and standardization at the request of any of the industries of Canada of the materials which are or may be used in, or of the products of, these industries making such a request.

"(2) The Institute shall have the charge, direction and supervision of the researches which may be undertaken under conditions to be determined in each case by or for single industrial firms or by such organizations, to be known as Trade Guilds for Research, as may desire to avail themselves of the facilities offered for this purpose by the Institute.

"15. The Governor in Council shall have power to direct, upon such conditions as he may prescribe that the scientific work or any part of the scientific work of any of the Departments of the Government or of any part of the public service or of any of the Commissions or Boards constituted by the Government shall, on and after such date or during such period as may be named in such order, be carried on by the Institute. Transfer of Scientific work to Institute.

"16. All discoveries, inventions and improvements in processes, apparatus or machines, made by the members or any number of members of the technical staff of the Institute shall be vested in the Council and be made available under such conditions and payment of fees or royalties or otherwise as the Council may determine, subject to the approval of the Sub-Committee. The Council, with the approval of the Sub-Committee, may pay to technical officers of the Institute and to others working under its auspices who have made valuable discoveries, inventions or improvements in processes, apparatus, and machines such bonuses as in its opinion the commercial or industrial value of such discoveries, inventions or improvements may warrant. Discoveries and inventions, control of.

Money, how to be expended.

"17. The money annually appropriated by Parliament for the work of the Institute, or which the Council may receive through bequest, donation or otherwise, shall be expended under the direction of the Council, subject to the approval of the Sub-Committee, for the carrying on of the work of the Institute.

Financial returns.

"18. All the receipts and expenditures received by or made on behalf of the Institute shall be subject to examination and audit by the Auditor General, and the Director of the Institute shall submit through the Council a statement of such receipts and expenditures to the Sub-Committee at such times and containing such details as the Sub-Committee may prescribe. A statement of receipts and expenditures during each fiscal year shall be laid by the Council before both Houses of Parliament within fifteen days after the close of the fiscal year if Parliament is then sitting, and if not, then within fifteen days after the opening of the then next session of Parliament.

Annual Report.

"19. A report of the work done by the Institute, containing such information and details as the Council and the Sub-Committee may require, shall be made by the Director to the Council and through the Council to the Sub-Committee after the close of each fiscal year, and the said report shall be laid before both Houses of Parliament."

APPENDIX "J"

LIST OF FELLOWSHIPS, STUDENTSHIPS AND BURSARIES, 1920-21

FELLOWSHIPS

Name	Where held	Subject of Research
H. J. C. Ireton	Department of Physics, University of Toronto	Part I. "Selected radiations emitted by specially excited mercury atoms." Part II. "Pieso-Electricity and its application to the measurement of Explosive Pressures."
J. A. McRae	Chemical Laboratories, Manchester University.	An investigation into the formation of substituted succinic acids from cyanoacetic aldehydes and hydrogen cyanide.
Miss M. Newton	University of Minnesota, St. Paul, Minn.	On biologic forms of wheat stem rust. (*Puccinia graminis*).
E. G. Young	Biochemistry Laboratory, Cambridge University.	1. Research on the optical rotation of crystalline ovalbumin and serum albumin. 2. The coagulation of protein by sunlight.
J. F. T. Young	Department of Physics, University of Toronto.	The crystal structure of magnetic alloys.
H. R. Foreman	Department of Physics, University of Toronto.	Resigned.
A. G. Shenstone	Department of Physics, University of Toronto.	Resigned.
F. H. S. Warneford	Department of Chemistry, McGill University.	Resigned.

STUDENTSHIPS

Name	Where held	Subject of Research
G. H. Berkeley	Department of Zymology, University of Toronto.	Fermentation of sulphite liquor.
J. W. Burns	Department of Chemistry, Queen's University.	Utilization of the common milkweed.
Miss C. W. Frits	Botanical Laboratory, University of Toronto.	An investigation on wood-destroying fungi.
C. Greaves	Department of Chemistry, McGill University.	Report on some attempts to prepare metallic beryllium
W. F. James	Department of Geology, McGill University.	The alteration of the quarts diabase dike at the Old Helen Mine, Michipocoten District, Ontario.
W. A. Lawrance	Chemistry Laboratory, University of Toronto.	Friedel and Craft's Reaction. Some substituted phthalic anhydrides with aluminium chloride and toluene.
A. H. Leim	Department of Biology, University of Toronto.	Study of the life-history of the shad.
J. W. McKinney	Department of Chemistry, McGill University.	The kerogen in oil shale.
Miss Irene Mounce	Department of Botany, University of Manitoba.	Monosporic cultures of some six species of *Coprinus* with a view to finding out whether or not monosporic Mycelia are able to produce fruit-bodies.
W. W. Shaver	Department of Physics, University of Toronto.	1. The absorption spectrum of liquid and gaseous oxygen. 2. Thalofide cell experiments.
P. V. Rosewarne	Department of Ind. Chemistry, McMaster University.	Deferred until 1921-22.
A. W. McCallum	Botanical Laboratory, University of Toronto.	Resigned.
J. H. Mennie	Department of Chemistry, University of British Columbia.	Resigned.

LIST OF FELLOWSHIPS, ETC.—*Concluded.*

BURSARIES

Name	Where held	Subject of Research
Miss M. Anderson	Bacteriology Laboratory, McGill University.	The growth of *B. pyocyaneus*, *B. typhosus*, *B. coli communis* and *B. coli communis* with *B. subtilis*.
A. H. Bell	Department of Geology, University of Toronto.	Special scholarship.
Miss E. M. Hill	Department of Chemistry, McGill University.	The autohydrolysis of fats.
A. B. Jackson	Department of Botany, University of Toronto.	On a group of parasitic fungi widely destructive of economic plants.
J. F. Lehmann	Department of Physics, University of Alberta.	On the properties of ultra-sonic oscillations.
O. A. Mackay	Department of Physics, Dalhousie University.	The effect of thermo-luminescence on electrical conductivity.
H. N. Stephens	Chemical Laboratory, University of Toronto.	Friedel and Craft's Reaction: Brom-phthalic anhydries with Benzene and Aluminium Chloride.
E. F. Whyte	Department of Chemistry, Dalhousie University.	A study of the extraction of potash from orthoclase feldspar by carbon dioxide and sulphur dioxide.
E. P. Dolan	Department of Geology, McGill University.	Deferred until 1921-22.
D. W. Bates	Department of Physics, University of Toronto.	Resigned.
Miss A. E. Dempsey	Department Biochemistry, University of Toronto.	Resigned.
P. Lowe	Department of Physics, University of Toronto.	Resigned.
W. E. Mooney	Department of Physics, University of Toronto.	Resigned.
G. M. Shrum	Department of Physics, University of Toronto.	Resigned.
J. A. Soaley	Department of Physics, University of Toronto.	Resigned.

APPENDIX "K"

LIST OF ASSISTED RESEARCHES, 1920-21

Grantee	Where carried on	Subject of Research	Amount awarded
			$ cts.
Forestry Branch, Department of the Interior, Ottawa.	Petewawa Forest Reserve.	Forestry studies	8,006 32
Prof. R. W. Boyle	Department of Physics, University of Alberta, Edmonton, Alta.	Research on ultra sonics embracing experiments to develop the transmission and reception in water of elastic (acoustic) waves of a very high periodicity and short wave lengths.	2,500 00
Prof. A. C. Neish	Department of Chemistry, Queen's University, Kingston, Ont.	Investigation on the utilization of the common milkweed as a substitute for flax; also, for the production of paint oil from the seeds and the production of insulation and other commercial materials from the coma.	250 00
Prof. Wilfrid Sadler	Department of Dairying, University of British Columbia, Vancouver, B.C.	To continue investigations on the grading of cream and butter in relation to the bacterial content of the cream or milk used in the preparation of these products.	1,000 00
Assoc. Committee on Industrial Fatigue.		To continue investigations on industrial fatigue problems in selected industries, with a view of supplementing the results of previous investigations.	3,000 00
Prof. J. B. Porter	Department of Mining Engineering, McGill University, Montreal, Que.	To complete investigation on the flotation method of separating Canadian ores, from different sources, by waste oils from wood distillation.	1,500 00
Associate Committee on Mining and Metallurgy.		Investigation on the utilization of the iron ores of Canada with a view to their utilization for the production of pig-iron and steel.	3,000 00
A. F. G. Cadenhead	Department of Metallurgy, Queen's University, Kingston, Ont.	To continue an investigation on the smelting of titaniferous iron ores.	5,000 00
H. Freeman	Special Laboratory, Vancouver, B.C.	Investigation of new processes for the separation of silver, lead and zinc in the concentrates of complex silver-lead-zinc sulphide ores of British Columbia.	10,000 00
Prof. F. M. G. Johnson, Prof. Otto Maass.	Department of Chemistry, McGill University.	Investigation of the surface energy of solids	85 0 0
Prof. J. C. McLennan	Department of Physics, University of Toronto.	To continue research on the liquefaction of helium.	3,000 00
Prof. J. C. McLennan	Department of Physics, University of Toronto.	Investigation of the spectrum of the infra-red rays, that is, the rays which are not revealed in the ordinary spectrum.	1,000 00
Associate Food Research Board.		Research on the isolation of a pure vitamine to determine its character.	1,200 00
Associate Committee on the problems of the Fox Industry.		To continue an investigation of the problems affecting the fox industry by means of an experimental ranch.	5,500 00
Prof. F. Allan	Department of Physics, University of Manitoba, Winnipeg, Man.	Research on colour vision	1,000 00

REPORT

OF THE

ADMINISTRATIVE CHAIRMAN

OF THE

HONORARY ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH OF CANADA

For the Year ending March 31, 1921

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